26946

National Library of Canada
Bibliothèque nationale du Canada

CANADIAN THESES ON MICROFICHE

THÈSES CANADIENNES SUR MICROFICHE

NAME OF AUTHOR/*NOM DE L'AUTEUR* E PATRICIA WALLACE (MRS.)

TITLE OF THESIS/*TITRE DE LA THÈSE* ECONOMETRIC ESTIMATES Of ADMINISTRATIVE AND NURSING SERVICE COST FUNCTIONS in the ALBERTA HOSPITAL SYSTEM.

UNIVERSITY/*UNIVERSITÉ* UNIVERSITY of ALBERTA.

DEGREE FOR WHICH THESIS WAS PRESENTED/ *GRADE POUR LEQUEL CETTE THÈSE FUT PRÉSENTÉE* M.H.S.A.

YEAR THIS DEGREE CONFERRED/*ANNÉE D'OBTENTION DE CE GRADE* 1975

NAME OF SUPERVISOR/*NOM DU DIRECTEUR DE THÈSE* DR. RICHARD PLAIN

Permission is hereby granted to the NATIONAL LIBRARY OF CANADA to microfilm this thesis and to lend or sell copies of the film.

The author reserves other publication rights, and neither the thesis nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

L'autorisation est, par la présente, accordée à la BIBLIOTHÈQUE NATIONALE DU CANADA de microfilmer cette thèse et de prêter ou de vendre des exemplaires du film.

L'auteur se réserve les autres droits de publication; ni la thèse ni de longs extraits de celle-ci ne doivent être imprimés ou autrement reproduits sans l'autorisation écrite de l'auteur.

DATED/*DATÉ* Oct. 17, 1975 SIGNED/*SIGNÉ* E. Patricia Wallace

PERMANENT ADDRESS/*RÉSIDENCE FIXE*
1031 McDermid Drive.
Sherwood Park
Alberta T8A 1B7

NL-91 (3-74)

THE UNIVERSITY OF ALBERTA

ECONOMETRIC ESTIMATES OF ADMINISTRATIVE AND NURSING SERVICE COST FUNCTIONS IN THE ALBERTA HOSPITAL SYSTEM

by

E. PATRICIA WALLACE ©

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF HEALTH SERVICES ADMINISTRATION

DIVISION OF HEALTH SERVICES ADMINISTRATION
DEPARTMENT OF COMMUNITY MEDICINE

EDMONTON, ALBERTA

FALL, 1975

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Econometric Estimates of Administrative and Nursing Service Cost Functions in the Alberta Hospital System submitted by E. Patricia Wallace in partial fulfilment of the requirements for the degree of Master of Health Services Administration.

Supervisor

Shirley M. Stinson

Dennis M. Baker

Date. Oct. 14/75

ABSTRACT

Econometric relationships between average general administration costs; average nursing administration costs; and average nursing service costs; and one output measure, the average number of admissions per bed during one year were estimated for a sample of General Public Hospitals in Alberta. Ordinary least squares regression analyses were applied using three models: linear; quadratic; and inverse form of the equation.

Empirical results for average general administration costs and average nursing administration costs for hospitals sub-divided according to size classes were observed to comply with theoretical expectations; however, estimated relationships for average nursing service costs were found to deviate from theoretical expectations for hospitals with less than one hundred beds. The possible reasons for this phenomenon are discussed.

Differences in estimated relationships between size classes were examined in lesser detail.

Relationships between the selected average costs and the selected output measure were estimated, and expected optimal case-flow rates were determined for hospitals grouped according to case-mix composition. Empirical results are reported and deviations from theoretical expectations are discussed.

ACKNOWLEDGEMENTS

The author wishes to acknowledge her gratitude to the following:

- Dr. Richard Plain for his guidance and patience and for many hours of valuable discussions.
- Dr. Shirley Stinson - a special acknowledgement for her professional leadership throughout two years of study and for her many helpful suggestions in the preparation of this thesis.
- Dr. Kyung Bay for his advice and assistance in computer programming.
- Dr. Dennis Baker for serving as a committee member.
- The Department of National Health and Welfare for research assistance in the form of a National Health Fellowship (Project Number 609-22-16) 1972-74.
- Friends and colleagues for their continuing encouragement and helpful discussions.
- The author's husband Herb for his support and understanding.

TABLE OF CONTENTS

ABSTRACT. iv

ACKNOWLEDGMENTS v

TABLE OF CONTENTS vi

LIST OF FIGURES viii

LIST OF TABLES. ix

Chapter

I. INTRODUCTION 1

Purpose and Objectives of the Study. 3
Specific Focus and Basic Method. 4
Limitations. 6
Definitions of Terms 7
  Pertaining to Hospitals and Functions. 7
  Pertaining to Costs. 9
  Pertaining to Output 10
Format. 10

II. REVIEW OF PERTINENT LITERATURE 11

General Economic Theory of Cost Functions. 11
  Cost Curves in the Short-Run 12
Major Empirical Short-Run Cost Studies in Industry . 19
Cost Studies in the Hospital System. 22
  The Measurement of Cost Functions. 24
  The Measurement of Hospital Output 26
  The Measurement of Homogenous Products 28
Empirical Short-Run Cost Studies in General Hospitals: A Summary Overview 32
Summary of the Literature Review 33

III. ECONOMETRIC ANALYSIS OF SHORT-RUN AVERAGE COSTS BY HOSPITAL SIZE CLASSES. 38

Introduction 38
Section I: The Analysis of Average General Administration Cost Relationships. 40
  Part 1: Average General Administration Costs and Case-Flow. 40
  Part 2: The Effect of Interclass Hospital Size Variations on Average General Administration Cost Relationships 46
Section II: The Analysis of Average Nursing Administration Cost Relationships. 50

Part 1: Average Nursing Administration Costs and Case-Flow 50
Part 2: The Effect of Interclass Hospital Size Variations on Average Nursing Administration Cost Relationships 55
Section III: The Analysis of Average Nursing Service Cost Relationships 58
Part 1: Average Nursing Administration Costs and Case-Flow 58
Part 2: The Effect of Interclass Hospital Size Variations on Average Nursing Service Cost Relationships 63
Section IV: Interhospital Differences in Rates of Responsiveness in Average Cost and Case-Flow . . . 67
Analysis of Covariance Results 67
Economic Observations: A Summary Overview 72

IV. ECONOMETRIC ANALYSIS OF SHORT-RUN AVERAGE COSTS ACCOUNTING FOR CASE-MIX VARIATIONS 74
Introduction 74
Section I: The Analysis of Average General Administration Cost Relationships 78
Part 1: Average General Administration Costs and Case-Flow 78
Part 2: Expected Optimal Case-Flow 84
Section II: The Analysis of Average Nursing Administration Cost Relationships 85
Part 1: Average Nursing Administration Costs and Case-Flow 85
Part 2: Expected Optimal Case-Flow 87
Section III: The Analysis of Average Nursing Service Cost Relationships 91
Part 1: Average Nursing Service Costs and and Case-Flow 91
Part 2: Expected Optimal Case-Flow 93
Economic Observations: A Summary Overview 97

V. SUMMARY OF MAJOR FINDINGS, OBSERVATIONS AND SUGGESTIONS 99
Summary 99
Observations and Suggestions 102

SELECTED REFERENCES 105

APPENDICES

A. RATED BED CAPACITY OF HOSPITALS IN SIZE CLASSES, ALBERTA GENERAL PUBLIC HOSPITALS, 1971 109

B. CLASSIFICATION OF 115 GENERAL PUBLIC HOSPITALS IN ALBERTA, 1971 ACCORDING TO CASE-MIX COMPOSITION. . . . 113

LIST OF FIGURES

1. Short-Run Total Fixed Cost 14
2. Short-Run Total Variable Cost. 15
3. Short-Run Total Fixed, Total Variable and Total Costs. . 16
4. Short-Run Average Fixed Cost 16
5. Short-Run Average Variable Cost. 17
6. Short-Run Average Total Cost 18
7. Short-Run Average Fixed, Average Variable, Average Total, and Marginal Costs. 18

LIST OF TABLES

1. Tabular Review of Selected Literature on Short-Run Cost Functions 34

2. Number of Hospitals in Size Classes and Percentage of Total - Alberta General Public Hospitals, 1971. . 40

3. Descriptive Statistics by Hospital Size Class, Alberta General Public Hospitals, 1971 41

4. Estimated Relationships Between Average General Administration Costs and Case-Flow by Hospital Size, Alberta General Public Hospitals, 1971 47

5. Estimated Relationships Between Average General Administration Costs and Case-Flow and Hospital Size, Alberta General Public Hospitals, 1971 49

6. Estimated Relationships Between Average Nursing Administration Costs and Case-Flow by Hospital Size, Alberta General Public Hospitals, 1971 54

7. Estimated Relationships Between Average Nursing Administration Costs and Case-Flow and Hospital Size, Alberta General Public Hospitals, 1971 56

8. Estimated Relationships Between Average Nursing Service Costs and Case-Flow by Hospital Size, Alberta General Public Hospitals, 1971. 62

9. Relationships Between Average Nursing Service Costs and Case-Flow and Hospital Size, Alberta General Public Hospitals, 1971 65

10. Descriptive Statistics for Total Sample and Hospitals Classified by Case-Mix, Alberta General Public Hospitals, 1971. 77

11. Estimated Relationships Between Average General Administration Costs and Case-Flow and Hospitals Size, Total Sample and Case-Mix Groups, Alberta General Public Hospitals, 1971 . . . 82

12. Expected Optimal Case-Flow for General Administration Cost Functions, Total Sample and Case-Mix Groups, Alberta General Public Hospitals, 1971 84

13. Estimated Relationships Between Average Nursing Administration Costs and Case-Flow and Hospital Size, Total Sample and Case-Mix Groups, Alberta General Public Hospitals, 1971 88

14. Expected Optimal Case-Flow for Nursing Administration Cost Functions, Total Sample and Case-Mix Groups, Alberta General Public Hospitals, 1971 90

15. Estimated Relationships Between Average Nursing Service Costs and Case-Flow and Hospital Size, Total Sample and Case-Mix Groups, Alberta General Public Hospitals, 1971 94

16. Expected Optimal Case-Flow for Nursing Service Cost Functions, Total Sample and Case-Mix Groups, Alberta General Public Hospitals, 1971 96

CHAPTER I

INTRODUCTION

"Too many people in too may beds are costing Canadian taxpayers too much money."[1] "Alberta, with seven hospital beds per 1,000 of population, has the highest ratio in Canada and perhaps in the world. . . and is said to be in deep trouble with rising health care costs."[2] Besides spending more on health care in general, Canadians spend more for hospital care, and the greatest increase is in the active treatment hospital. This is explainable, in that "the hospital is the largest subsector of the health care section, and has grown the fastest."[3] Between the years 1955 and 1967, hospital service expenditures increased fourfold, from $480 million to $1.9 billion.[4]

There are many reasons for the rise in hospital care costs. Hospital services are labour intensive, and the prices for services of professional and non-professional employees are constantly increasing. "Wages, or the remuneration for work, account for eighty percent of health services costs in general and seventy percent of hospital care costs."[5] Approximately fifty percent of the total expenditures on wages and salaries is attributable to nursing service personnel.

---

[1] The Financial Post, 16 December 1972, p. 14.

[2] Financial Times of Canada, 8 January 1973, p. 5.

[3] R.D. Fraser, Canadian Hospital Costs and Efficiency (Ottawa: Information Canada, January 1971), p. 2.

[4] Jean-Luc Migué and Gérard Bélanger, The Price of Health (Toronto: The Macmillan Company of Canada Limited, 1974), p. 101.

[5] Ibid., p. 116.

Other factors which contribute to spiralling hospital costs are continued increases in the cost of drugs and medical and surgical supplies; rising food costs per meal day; increasing equipment costs; climbing maintenance and plant operation costs; and inappropriate utilization of hospital services, to name a few.[1] Even empty hospital beds are expensive, for there is evidence that "on the average, an empty hospital bed is about 75 percent as expensive as an occupied bed."[2] "On several occasions, the Task Force Reports on the Cost of Health Services in Canada have deplored the fact that many hospital beds and facilities are not always used fully."[3] There are, however, no pertinent data to support this statement. It is becoming mandatory for hospital administrators "to establish and apply some flexible yet effective criteria for bed utilization, that is to control patient length of stay without deterring from the quality of patient care."[4]

Capacity utilization in hospitals of a given size as determined by the number of beds, will vary. It follows that the average cost of services which hospitals provide will also vary, depending upon whether or not capacity is being fully utilized.

---

[1] Graham Simms, "A Critical Review of Fiscal and Administrative Controls on Costs and Use in Canada," Medical Care 7 (November-December 1969): 72-4.

[2] Ralph E. Berry, "Returns to Scale in the Production of Hospital Services," Health Services Research 2 (Summer, 1967): 123.

[3] Migué and Bélanger, p. 25.

[4] J.S. Fair, "A Concrete Approach to More Effective Bed Utilization," Hospital Administration in Canada 12 (July 1970): 41.

Purpose and Objectives of the Study

The relationship between short-run average costs and the level of hospital utilization has important implications for decision-making with regard to efficient use of hospital facilities. The purpose of this study is to shed some light on selected aspects of economic behaviour in general public hospitals in Alberta.

Several investigators, notably, Feldstein[1] and Fraser[2] have carried out studies aimed at identifying and estimating costs relevant to decision-making in hospitals in the public sector. Feldstein maintains that hospital size may influence not only cost, but the quality of care provided, as well as the cost of distributing hospital services.[3] Fraser postulates that "traditionally there are thought to be internal diseconomies associated with overall administrative activities as the level of output increases."[4]

The research objectives underlying this study are two-fold: first, to estimate selected short-run average cost functions in general public hospitals in Alberta; and second, to determine to what extent the cost-output relationships comply with theoretical expectations. Specifically, the investigator proposes to deal with the following questions:

1. What are the estimated relationships between the selected average costs and case-flow rates in hospitals subdivided by size classes?

---

[1] Martin S. Feldstein, Economic Analysis for Health Service Efficiency (Chicago: Markham Publishing Company, 1968), pp. 1-303.

[2] Fraser, pp. 1-159.

[3] Feldstein, p. 56.

[4] Fraser, p. 45.

2. What are the effects of variation in plant capacity on the estimated cost relationships within the hospital size classes?
3. What are the interhospital differences in the rates of responsiveness between average costs and case-flow rates?
4. What are the estimated relationships between the selected average costs and case-flow rates in hospitals grouped according to case-mix composition?
5. What are the expected optimal case-flow rates for each cost function for hospitals classified according to case-mix?

Specific Focus and Basic Method

This study focuses on examining the relationships of three average hospital costs as they relate to one measure of hospital output, that of capacity utilization expressed as the case-flow rate. The average costs examined are: expenditures on general administration; nursing administration; and nursing services.

By looking at selected average cost functions rather than total cost functions, it is possible to gain a greater understanding of the behaviour of costs. In empirical analyses, average cost curves minimize economic problems.[1]

Estimations are given in the short-run through the use of cross-sectional analyses. This is a feasible technique as there are separate measures of capacity (hospital size) and output (the number of cases);

---

[1] For the justification of the use of average cost curves, refer to Felstein, p. 28.

thus by holding plant capacity constant, the effect on average costs can be examined as they relate to other variables, in this case, output. The method of cross-sectional estimations used in this study departs from the traditional short-run cost estimations made with time-series data for one firm in which plant capacity remains fixed over a short period of time,[1] and corresponds to that carried out by Feldstein.[2]

The study data are derived from 1971 Financial and Statistical Tables for Alberta Hospitals, compiled by the Alberta Hospital Services Commission on a sample of 115 general public hospitals, which is considered to be relatively homogeneous with regard to diagnostic mix, facilities and services.

This study is empirical, descriptive and exploratory in nature. Estimated relationships between average costs and output were obtained by applying ordinary least squares regression analyses using three models: linear; quadratic; and the inverse form of the equation. The data were analyzed firstly on the 115 hospitals grouped according to size classes; and secondly on the total sample, as well as hospitals classified according to case-mix composition.[3] Analysis of covariance was used to determine interhospital differences in rates of responsiveness for hospitals grouped according to size classes. Optimal case-flow rates for the total study sample and hospitals classified according to case-mix were calculated by taking partial derivatives of the quadratic equations.

---

[1] For a detailed explanation of criteria for short-run analyses, refer to J. Johnston, Statistical Cost Analysis (New York: McGraw Hill Book Company Inc., 1960), pp. 26-30.

[2] Feldstein, p. 129.

[3] See chapter III and chapter IV for detailed discussions on hospital size classes, and case-mix composition respectively.

Limitations

In order to provide a relatively homogenous sample of hospitals, only general public hospitals were considered in this study. For this reason, the Dr. W. W. Cross Institute, Edmonton, and the Alberta Children's Provincial General Hospital, Calgary, were excluded from any analyses, although they are considered to be general public hospitals. Similarly, this study does not include those hospitals owned and operated by the Federal Government, Auxiliary Hospitals, or Contract Hospitals. The study findings, therefore, pertain only to the remaining general public hospitals in Alberta.

Since the investigator was concerned with estimating cost-output relationships for hospitals classified according to case-mix composition, it was necessary to use 1971 data, as to the investigator's knowledge no attempt had been made prior to that year, or subsequently, to classify Alberta hospitals in this manner.[1]

The question of output is a complex one. There are several measures of hospital output which could be considered in the estimation of cost functions, the most common measure being the number of patient days. One could argue that output should properly be based upon direct measurement of patients' well-being, which is qualitative measurement to a large extent. "Many if not most hospital cost studies have floundered on the appropriate definition of those outputs whose costs are to be measured."[1] This study, however, is limited to one basic unit of output: the number of cases treated. Feldstein argues that the case as an output measure is superior to any other measure, as it includes both live discharges and deaths.[2] The average cost per patient day or hospital day is not reflective of actual costs. If a patient's length of stay were reduced the cost per day might increase, which would result in an artificial measure of inflation. The cost per patient day does not in any way allude to the effectiveness or benefit of a day of hospital care.[3]

---

[1] K. Bay, D. Flathman, and R. Plain, "An Application of Q-type Factor Analysis for Grouping Hospitals Based on Case-Mix Profiles," Division of Health Services Administration, The University of Alberta, 1971. (Mimeographed.)

Finally, although there are many hospital expenditures which would be useful to examine, this study is limited to three cost indices, which represent only a portion of a hospital's operating costs.

Definitions of Terms

Definitions Pertaining to Hospitals and Functions

General Public Hospital: applies to a hospital which is recognized by the province as a "public hospital." It is not operated for profit, and accepts all patients regardless of their ability to pay. It "provides for the treatment and care of all types of diseases without restriction as to age group or sex."[4]

---

[1] Sylvester E. Berki, Hospital Economics (Toronto: D.C. Heath and Company, 1972), p. 31.

[2] Feldstein, p. 25.

[3] Martin S. Feldstein, The Rising Cost of Hospital Care (Washington: Information Resources Press, 1971), pp. 20-21.

[4] 1972 Instructions and Definitions for the Annual Return of Hospitals - Form HS-1 Facilities and Services (Ottawa: Statistics Canada - Department of National Health and Welfare, 1972), p. 6, hereafter referred to as Form HS-1.

Number of Beds: a hospital's rated bed capacity.

General Administration: "the centre to which are allocated the costs of providing administrative direction and for carrying out business office, fiscal and personnel functions of the hospital."[1]

Nursing Administration: "the unit to which is assigned the responsibility for the general management of nursing services. Depending on the size of the organizational structure of the hospital, this may include: (a) the Nursing Director,[2] (b) Assistant or Associate Nursing Directors, (c) Supervisors who assist in the management of the nursing service as a whole, (d) such other nursing clerical or stenographic staff, as are assigned to the Nursing Administration office."[3]

Nursing Services: nursing services does not include any of the functions of medical staff nor of interns, residents or students. Nursing services are defined as follows: "1) Nursing Administration; 2) Nursing Units--Adults and Children, (a) short-term unit, and (b) long-term unit; 3) Newborn Nursing; 4) Delivery Room; 5) Operating Room (including Post-operative Recovery Room); 6) Emergency Unit; 7) Central Supply Room; 8) Occupational Therapy (unless organized as a special entity); 10) Other Specified Nursing Services."[4]

Case-Mix: the proportion of cases in specified disease categories.[5]

Hospital Size Classes: the sample of 115 general public hospitals in Alberta subdivided into five groups of hospitals, as determined by rated bed capacity.[6]

---

[1] Ibid., p. 27.

[2] The exception is where the director of nursing also functions as the chief executive officer of the hospital. In this situation she will be included under General Administration.

[3] 1972 Instructions and Definitions for the Annual Return of Hospitals - Form HS-2. Financial (Ottawa: Statistics Canada - Department of National Health and Welfare, 1972), p. 7, hereafter referred to as Form HS-2.

[4] Form HS-1, pp. 29-30.

[5] For an explanation of case-mix for purposes of this study, refer to chapter IV, p. 76.

[6] See chapter III, p. 40.

Definitions Pertaining to Costs

Costs refer to average costs, calculated from gross expenditures on an accrual basis of operating and maintaining hospitals during the year 1971.

Expenditures on General Administration:

1. Salaries and wages earned during the year by all staff whose salaries are chargeable to this expense centre which includes: the administrator, medical director, medical staff remuneration, chaplain, chief financial officer, personnel officer, co-ordinators or instructors in staff training and the supervisory and office staff performing the function of general administration.[1]
2. Supplies and Other Expenses (excluding medical and surgical supplies and drugs).[2]

Expenditures on Nursing Administration:

1. Salaries and wages of nursing administration personnel.
2. Supplies and other expenses (excluding medical and surgical supplies and drugs).[3]

Expenditures on Nursing Services:

1. Salaries and wages of nursing personnel, including those of nursing administration and other service areas as listed on page 8 of this study.

---

[1] Form HS-2, p. 12.

[2] These costs relate to the following: advertising; association membership fees; bonding and insurance; business machine expenses; collection fees; interest on short-term loans; interest on long-term loans; postage; printing stationery and office supplies; audit and accounting fees; other professional fees; service bureau fees; staff training; telephone and telegraph; indemnity to board members; travel and convention expenses (a) by board members (b) by staff; carfare and local travel; other supplies and expense. Source: Form HS-2, pp. 16-18.

[3] Form HS-2, p. 7.

2. Supplies and other expenses including medical and surgical supplies and drugs.[1]

Definition Pertaining to Output

Case-flow Rate: the average number of admissions per bed during the year 1971, used interchangeably with capacity utilization.

Format

The study is reported in terms of four main sections: chapter II consists of a discussion of the theory of cost and a review of the relevant literature on cost relationships in industry, and general hospitals in the health care sector. Chapter III presents the econometric analysis of short-run average costs by hospital size classes. Chapter IV contains the econometric analysis of short-run average costs accounting for case-mix variations. In chapter V, a summary of the major findings of the study is presented and observations and suggestions are made. A list of the total study sample of hospitals according to size class and rated bed capacity, and a breakdown of hospitals as determined by case-mix composition are provided in the appendices.

---

[1] 1971 Financial and Statistical Tables for Alberta Hospitals (Alberta Hospital Services Commission, 1971), pp. 69-72.

CHAPTER II

REVIEW OF PERTINENT LITERATURE

In the review of selected literature, the investigator has focused on the following: general economic theory of cost functions, comprising an overview of total and average cost functions; brief descriptions and findings on the major empirical short-run cost studies in industry; a discussion of some of the problems encountered in measurement techniques in hospital cost studies; and a tabular summary of the relevant studies and findings on short-run cost functions in the hospital system.

General Economic Theory of Cost Functions

> A firm's cost functions show various relationships between its costs and its output rate. The firm's production function and the prices it pays for inputs determines the firm's cost functions. Since the production function can pertain to the short-run or the long-run, it follows that the cost functions can also pertain to the short-run or the long-run.[1]

Leftwich emphasizes that the costs at each output depend not only on the "amount the firm must pay for its resources, but also the efficiency with which the firm uses the resources."[2]

Mathematically, the cost-function may be expressed as:

$$C = f\ (Q,\ P_i)$$

---

[1] Edwin Mansfield, Microeconomics Theory and Application (New York: W.W. Norton and Company Inc., 1970), p. 159.

[2] Richard H. Leftwich, The Price System and Resource Allocation (Illinois: The Dryden Press Inc., 1970), p. 146.

where C is the total cost of production which is a function of Q, the firm's output, and P_i, the price of the inputs. (i, = 1, 2, 3 . . . n).[1] It is assumed that the price of each input remains constant, regardless of the quantity purchased.[2]

In the short-run, the firm has a fixed scale of plant which establishes the upper limit to the amount of output achievable within a period of time. According to Leftwich, "any time period between that in which no resources can be varied in quantity and that in which all resources but one are variable can legitimately be called the short-run.[3] Johnston maintains that in order to meet the requirements for testing short-run cost-output relationships, a wide spread of output observations at varying rates is necessary, and that the study data should not be contaminated by extraneous factors in the cost-output relationship, such as variations in prices paid for the factors of production.[4]

Cost Curves in the Short-Run

There are three total cost curves which will be considered in this discussion: total fixed cost curves; total variable cost curves; and total costs. Correspondingly, there are three unit cost curves: average fixed cost curves; average variable cost curves; and average total cost curves. Although marginal cost, which is "the ratio of the increase in cost to the increase in output for a small increment in output"[1] has a special relationship to the average cost curve, it will be discussed very briefly in this study.

---

[1] Charles F. Riley, "An Examination of the Economic Literature Pertaining to the Behaviour of Costs in General Hospitals" (M.H.S.A. thesis, University of Alberta, 1974), p. 37.

[2] Kelvin Lancaster, Introduction to Modern Microeconomics (Chicago: Rand McNally and Company, 1969), p. 95.

[3] Leftwich, p. 147.

[4] Johnston, pp. 26-27.

Total Fixed Cost Curves

In the short-run with a fixed scale of plant, the firm experiences fixed costs. Total fixed cost curves are horizontal by definition,[2] and are not affected by any variation in output.[3] These costs would include amortization costs, depreciation cost of the physical plant, heavy machinery, and the salaries of top management.[4, 5] Friedman claims that a fixed cost is "a minimum sum which the firm is committed to pay to factors of production no matter what it does, and no matter how its actions turn out."[6] Figure 1 illustrates the shape of a short-run total fixed cost curve.

---

[1] Lancaster, p. 110

[2] Paul A. Samuelson and Anthony Scott, Economics (Toronto: McGraw Hill Company of Canada Limited, 1971), p. 566

[3] Mansfield, p. 160.

[4] Leftwich, p. 160.

[5] Riley, pp. 39-40.

[6] Milton Friedman, Price Theory (Chicago: Aldine Publishing Company, 1967), p. 98.

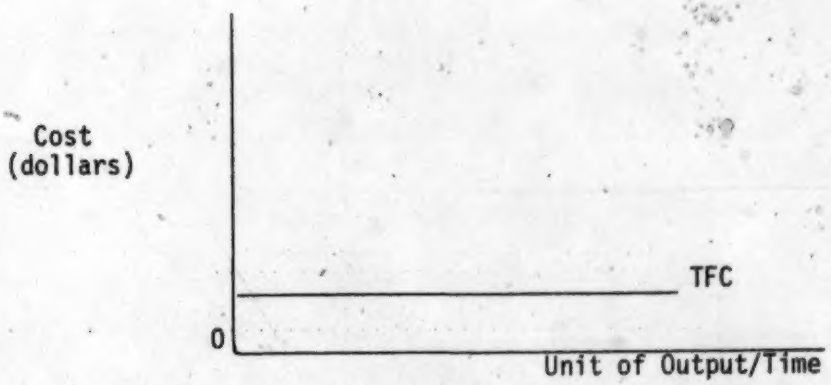


Figure 1

SHORT-RUN TOTAL FIXED COST

Total Variable Cost Curves

In the short-run, variable costs portray the costs incurred by the firm for variable inputs. In this case, variable cost curves rise as the output of the firm increases, "since larger outputs require larger quantities of variable resources, and thus larger cost obligation."[1] Up to a certain output level, however, total variable costs increase at a decreasing rate. Beyond that output level, the rate of increase in total variable costs rises, resulting in diminishing marginal returns.[2, 3, 4] Variable costs account for all items of total costs excluding fixed costs, and include input items such as raw materials and labour costs.

Figure 2 depicts the shape of a total variable cost curve.

---

[1] Leftwich, p. 149.

[2] Ibid., p. 149.

[3] Mansfield, p. 162.

[4] Samuelson and Scott, p. 31.

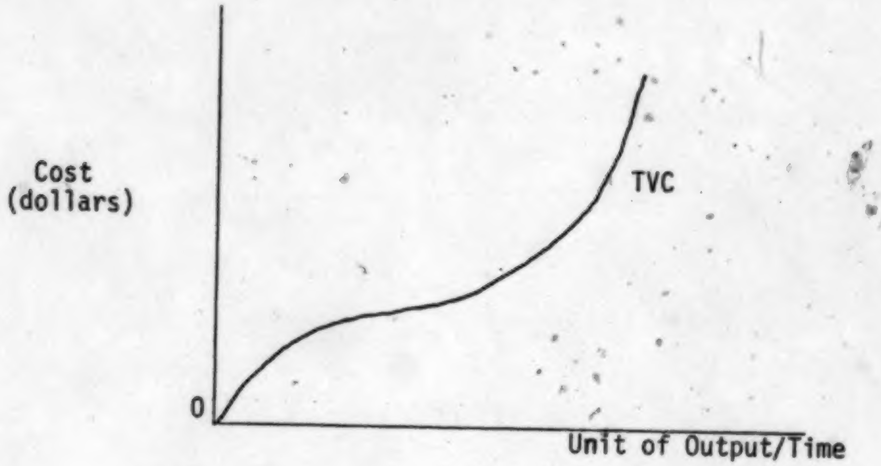


Figure 2

SHORT-RUN TOTAL VARIABLE COST

With reference to the above figure, the traditional S-shaped variable cost curve is depicted.[1]

Total Cost Curves

Total cost for each level of output is the summation of total fixed costs and total variable costs.

Since the total cost curve and the total variable cost curve differ only by the total fixed cost curve, both increase at the same rate per unit of time and, therefore, are the same shape. "The total cost curve lies above the total variable cost curve by an amount equal to the total fixed cost at all output levels."[2]

Figure 3 depicts all of the total cost functions together.

---

[1] Refer to Lancaster, chapters IV and V, for a detailed explanation of the rationale underlying a wide range of production and cost models. In the case under discussion, the traditional production model has been assumed to hold.

[2] Leftwich, p. 152.

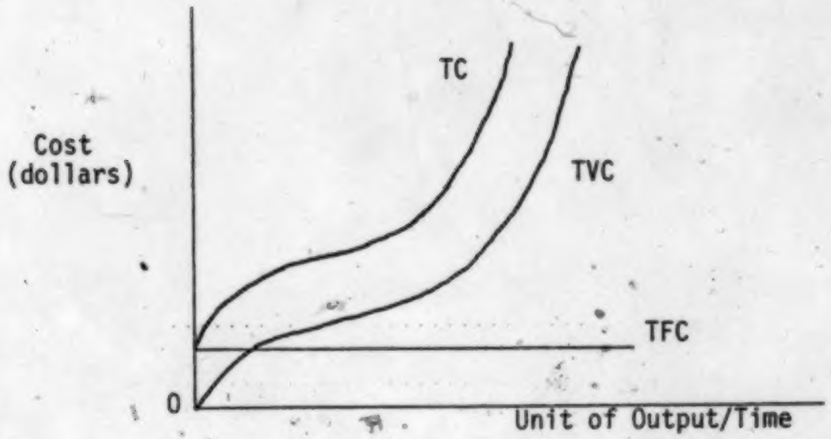


Figure 3

SHORT-RUN FIXED, VARIABLE AND TOTAL COSTS

Average Fixed Cost Curves

The average fixed cost is the total fixed cost divided by the output.[1, 2] As the firm's output becomes greater, the average fixed cost decreases. The curve is downward sloping to the right throughout the entire range of output. It approaches, but does not reach the horizontal (output) axis. Theoretically this curve is the shape of a rectangular hyperbola,[3] as illustrated in Figure 4.

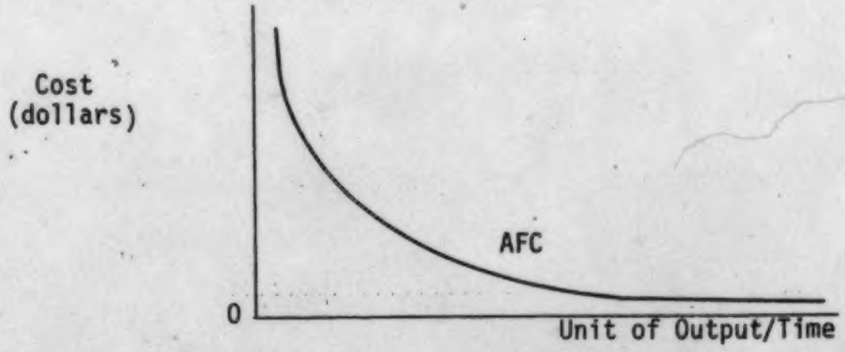


Figure 4

SHORT-RUN AVERAGE FIXED COST

---

[1] Ibid., p. 154.

[2] Mansfield, p. 163.

[3] Ibid., p. 163.

Average Variable Cost Curves

The average variable cost curve is the per unit cost which corresponds to the total variable cost. It is ordinarily a U-shaped curve. Initially, as output expands, variable costs decrease and reach a minimum. Beyond a certain output level, these costs begin to rise. This phenomenon can be most readily explained in terms of the theory of production.[1]

Figure 5 depicts the shape of an average variable cost curve.

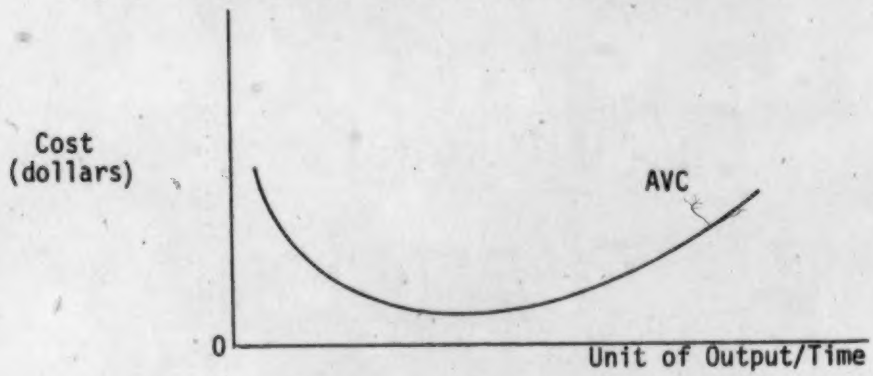


Figure 5

SHORT-RUN AVERAGE VARIABLE COST

Average Total Cost Curves

The average total cost is the summation of the average fixed cost and the average variable cost, or conversely, the total cost divided by the output. When only one unit is produced, the average cost is equal to the total cost. As output increases, the average cost decreases until it reaches a minimum point (optimal output level). As variable resources become less efficient, the efficiency of the fixed resources consequently becomes reduced and the average total cost curve begins to rise slowly.[1, 2, 3] This relationship principle in terms of a U-shaped curve is expressed in Figure 6.

---

[1] For a detailed discussion of the production function, see Mansfield, chapter V, pp. 126-132.

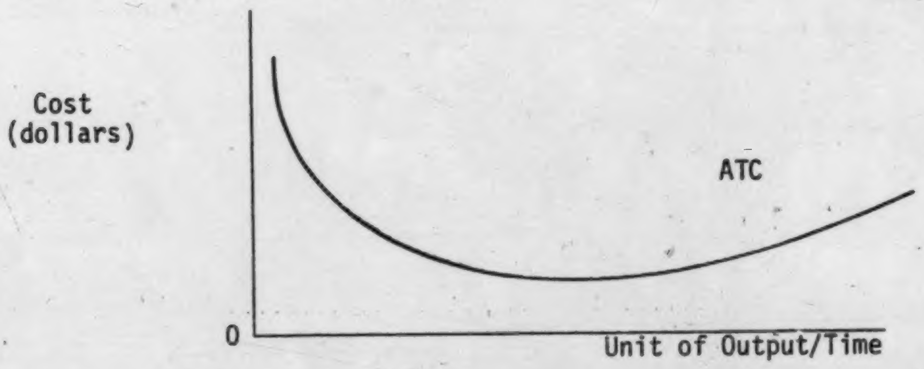


Figure 6

SHORT-RUN AVERAGE TOTAL COST

Figure 7 depicts the relationship between the three average cost curves, and the marginal cost curve.

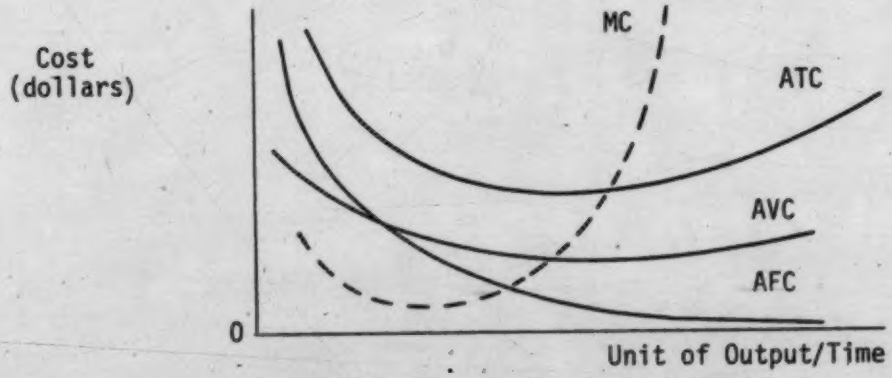


Figure 7
SHORT-RUN AVERAGE FIXED, AVERAGE VARIABLE,
AVERAGE TOTAL, AND MARGINAL COSTS

---

[1] Samuelson and Scott, p. 568.

[2] Mansfield, p. 165.

[3] Leftwich, p. 155.

Summary

The total costs and their resulting curves contain all cost information. Average costs contain all the information of total costs, since by multiplying average costs by output, total costs may be calculated. Thus, average costs do not provide any additional information, however, they sometimes simplify analyses. Marginal costs are independent of fixed costs, since they depend entirely on variable costs. In sum:

> Average cost rises with output if and only if marginal cost exceeds average cost; average cost falls with output if and only if average cost exceeds marginal cost; and average cost is steady if and only if marginal and average costs are equal.[1]

Major Empirical Short-Run Cost Studies in Industry

The purpose of the review of literature pertaining to empirical short-run cost studies in industry is to provide a background of information upon which to compare approaches and findings with those studies carried out in the health care sector, although it is recognized that input and output measures are unquestionably dissimilar due to the distinctive nature of the firms.

Joel Dean

Dean's empirical study published in 1941 on short-run cost functions in a hosiery mill was one of the pioneer attempts at measuring a firm's cost function. Data on output rates for one mill were collected from 1935 to 1939. The output rate varied considerably over that period of time, with the size of the plant remaining fixed. Initially estimated cost-output relationships were obtained using total cost, which were deflated by factor price indices.[1] "With respect to average cost Dean concluded that neither the cost observations nor their group averages show any consistent tendency to rise over the extremely high levels of output."[2]

---

[1] Lancaster, p. 122.

Eiteman and Guthrie

In order to determine the shape of an average cost curve, the authors sent mail questionnaires to 1,000 manufacturing companies in 47 American States.[3] The criteria was that these companies had more than 500 but less than 5,000 employees. The questionnaire consisted of eight graphs representing average cost curves, accompanied by explanations as to their meanings. An average cost curve was defined as:

> . . .a line on a graph which shows the cost per product at each possible scale of operation from the minimum to the maximum (excluding all overtime work). At each scale of operation, the average cost is computed by dividing total cost of production allocated to a product by the quantity of the product produced.[4]

The respondents were to indicate which curve most closely represented the cost function for their main products.

---

[1] Joel Dean, "Statistical Cost Functions of a Hosiery Mill" in Statistical Cost Analysis, ed. J. Johnston (New York: McGraw Hill Book Co., Inc., 1960), pp. 138-139.

[2] Johnston, p. 139.

[3] Wilfred J. Eiteman and Glenn E. Guthrie, "The Shape of an Average Cost Curve," American Economic Review 42 (1952): 832.

[4] Ibid., p. 833.

Of the 366 replies (from 32 states), 334 selected one curve which applied to all products of the company.[1] Of the total, 113 companies indicated an average cost curve with a fairly rapid decline to a levelling point, followed by a slight increase at the end of the output range, whereas 203 companies chose an average cost curve with a continual decrease throughout the entire output range.[2] Johnston contends that the results would suggest a contradiction to theoretical expectations.[3] Walters argues that "the questionnaire studies are methodologically suspect, and very little weight can be placed upon their conclusions."[4]

Markham

Markham's study published in 1952, deals with short-run cost functions in one rayon producing plant.[5] "One curve shows relative unit cost as a function of capacity utilization."[6] Results of the study on the short-run function show that

> . . . unit costs rise at an increasing rate as output is curtailed and commence to increase immediately with curtailment below 100 percent of installed capacity. The shape of the curve is attributable for the most part to a high proportion of overhead costs and the relative inflexibility of operations.[7]

---

[1] Ibid., p. 837. [2] Ibid., p. 835, 837 [3] Johnston, p. 142

[4] A.A. Walters, "Production and Cost Functions: An Economic Survey," Econometrica 31 (January 1973): 51.

[5] Jesse W. Markham, "Competition in the Rayon Industry," in Statistical Cost Analysis, ed. J. Johnston (New York: McGraw Hill Book Company Inc., 1969), p. 147.

[6] Johnston, p. 147. [7] Ibid., p. 147.

The curve approximates the short-run cost-curve of economic theory.[1]

Johnston

In a time series study on the relationship between costs and output on road passenger transport firms, Johnston estimated short-run curves for firms of different sizes.[2] Costs were defined as total deflated expenses (wages, fuel costs, maintenance and depreciation, and other traffic costs). The number of car miles was a basic decision variable. Applying least squares regression analyses, Johnston found that the short-run average cost function was estimated to be "downward and sloping to the right throughout its entire length, an increase of ten percent in output being associated on the average with a three percent reduction in average costs per unit of output."[3]

Cost Studies in the Hospital System

There is a paucity of published data on cost-output relationships in the health care sector within the hospital field for a variety of reasons. Brown advances the explanation that the hospital has not been viewed as a firm which produces goods and services for consumption, and therefore has not been seen as being of significance to researchers concerned with economic analysis.[4] Newhouse states that the hospital is a non-profit firm, and for this reason has been ignored by economists until very recently.[1] According to Greenfield, most firms are business entities that seek to generate profit from their production activities,[2] and, unlike most production firms, the objective of a hospital cannot be defined in terms of profit maximization.[3] Klarman points out that the special distinguishing features of health services such as an unpredictable and irregular incidence of illness, the highly labour intensive aspects of the hospital industry which results in a faster rising increase in costs and prices than for most other goods and services, and certain other unusual characteristics of inputs and outputs constitute problems in cost analyses.[4]

---

[1] Ibid., p. 147

[2] Johnston, p. 74.

[3] Ibid., p. 83.

[4] Max Brown, "An Economic Analysis of Hospital Operations," Hospital Administration 15 (1970): 60.

Central to the issue is the lack of standard measures which can be applied to hospital costs and hospital output. Chiefly, the absence of well-defined standards or measures appear to fall within three broad categories: the measurement of cost functions; the definition of hospital output; and the absence of a homogeneous product upon which to base cost-output functions. "Components of the largest activity (in-patient care) are extremely variable across hospitals with respect to severity and diagnosis.[5]

---

[1] Joseph P. Newhouse, "Toward a Theory of Non-Profit Institutions: An Economic Model of a Hospital, American Economic Review (March 1970): 64.

[2] Harry I. Greenfield, Hospital Efficiency and Public Policy (New York: Praeger Publishers, 1973), p. 6.

[3] Sylvester E. Berki, Hospital Economics (Lexington, Massachusetts: D.C. Heath and Company, 1972), p. 19.

[4] Herbert E. Klarman, The Economics of Health (New York: Columbia University Press, 1965), pp. 10-18.

[5] Robert G. Evans and Hugh D. Walker, "Information Theory and the Analysis of Hospital Cost Structure," The Canadian Journal of Economics 5 (August 1972): 399.

The Measurement of Cost Functions

Studies pertaining to hospital cost functions reported in the literature refer primarily to three costs: total costs using time-series or cross-sectional data; average costs using time-series or cross-sectional data and marginal costs. Hospital costs are commonly classified in terms of operating costs and capital costs. "In the literature, capital costs were generally overlooked."[1] Evans states:

> . . . existing data do not permit one to estimate the capital costs of providing hospital care. Thus our data overstate hospital inpatient costs insofar as they include part of the overhead cost of educational programs, outpatient clinics, etc., and understate costs insofar as they exclude the costs of capital services.[2]

Montachute questions whether cost studies should be limited to prime costs, which are direct costs including salaries and wages of staff and supplies purchased for the hospital departments concerned, or whether indirect expenses should also be included.[3] He argues, however, that direct costs plus indirect expenses are both necessary in determining total costs. Montachute further concludes that total departmental costs are the only reliable costs to use for comparison.[4] Some authors, notably P. Feldstein,[5] who was one of the first researchers in hospital costs, and M. Feldstein,[1] consider departmental costs in detail. Berki contends that no detailed analysis of providing out-patient services has been carried out in hospital cost studies.[2] It is possible that cost studies involving estimations between total hospital operating costs and measures of in-patient services could bias the results, as these costs may in fact reflect the costs of out-patient services excluded from analyses.

---

[1] Riley, p. 116.

[2] R.G. Evans, "Behavioural Cost Functions for Hospitals," Canadian Journal of Economics 4 (May 1971): 199.

[3] Charles Montachute, Costing and Efficiency in Hospitals (London: Oxford University Press, 1962), p. 170.

[4] Ibid., p. 173.

[5] Paul J. Feldstein, An Empirical Investigation of the Marginal Cost of Hospital Services (Chicago: University of Chicago, 1961), pp. 14-48.

An example involving the above considerations is a study done by Evans.[3] Costs of in-patient activity were derived by "subtracting from each hospital's total expenditure the direct costs of all non in-patient activities such as education, research, and out-patient care."[4] Similarly, Martin Feldstein excluded all out-patient costs in his analyses.[5]

In sum, there appear to be two main difficulties in cost studies in the hospital sector. With the exception of the study carried out by Fraser[6] capital costs were generally omitted by most other authors. As capital costs are a part of the overall cost of providing hospital services, omission of capital costs from analyses could result in unreliable cost estimates. The second major difficulty in hospital cost studies pertains to the definition of cost. It is noted in the literature that some authors consider departmental costs, while other researchers focus on total operating costs. Thus, there is very little consistent basis upon which to compare hospital cost findings. Evans and Walker maintain that estimations of cost functions in Canadian hospitals is becoming a "growth industry."[1] It would stand to reason that until such time as there is a common basis for measuring cost functions, no consensual view on the short-run cost behaviour in hospitals will be possible.

---

[1] Feldstein, Economic Analysis for Health Service Efficiency, pp. 12-14.

[2] Berki, p. 116.

[3] Evans, pp. 198-213.

[4] Ibid., p. 199.

[5] Feldstein, Economics Analysis for Health Service Efficiency, p. 22.

[6] Fraser, pp. 1-159.

The Measurement of Hospital Output

The hospital is a complex organization of departments which offer a variety of services, including in-patient services, out-patient services, education, research and community services. Berki points out that it is the "complexity of the medical processes and the multiplicity of its services that make output identification difficult."[2] The problem of output measurement has perplexed many researchers in the area of hospital cost studies.

According to Berki, there are six basic approaches to the definition of hospital output:

1. Patient Days, weighted or unweighted
2. Hospital Services
3. Episode of illness
4. End-results and health levels
5. Intermediate inputs
6. Composites of one or more of the above.[3]

---

[1] Evans and Walker, p. 398.

[2] Berki, p. 31.

[3] Ibid., pp. 33-34.

The most widely accepted definition of output in the literature is patient days.[1, 2, 3] Greenfield supports the use of patient days as the output measure if the objective is to determine hospital efficiency.[4] Several authors agree that the patient day as measure of output must be viewed with scepticism, particularly when comparing one hospital with another.[5, 6] Berki suggests that the difficulty in measuring output on the basis of the patient day stems from the fact that the patient day is a gross aggregate.[7] This approach implies that all patient days are alike and, further, ignores the fact that within each patient day are a combination of services, which are provided by the various hospital departments, such as admission services, diagnostic services, nursing services, and "hotel" services. One author, Martin Feldstein, developed a measure of output, that being the number of cases treated by a hospital. By controlling for case-mix and the number of special services performed, he was able to obtain a degree of homogeneity of his output measure. The central problem in using the number of cases

---

[1] Ralph E. Berry, "Returns to Scale in the Production of Hospital Services," Health Services Research 2 (Summer 1967): 134.

[2] Edward M. Kaitz, Pricing Policy and Cost Behaviour in the Hospital Industry (New York: Praeger Publishers, 1968), p. 16

[3] Judith R. Lave and Lester B. Lave, "Hospital Cost Functions," American Economic Review 60 (June 1970): 380.

[4] Greenfield, p. 21.

[5] Lave and Lave, p. 380.

[6] John D. Thomspon, "On Reasonable Costs of Hospital Services," Millbank Memorial Fund Quarterly 46 (January 1968): 35.

[7] Berki, p. 34.

as the output measure, was that it did not control for discharge status and hospital transfers.[1] Out-patient care was definitely excluded from his definition of output. Greenfield states that using the admissions measure alone would not provide information as to the amount and types of resources used.[2]

Clearly, the measurement of hospital output is a difficult task, and there appears to be no agreement among researchers on what the appropriate definition should be. Recent approaches, however, which account for case-mix specification "have the promise of providing the output identification required to focus on the economic issues of production and efficiency."[3]

The Measurement of Homogeneous Products

"One possible approach to capture the heterogeneity of the patient day is to adjust for case-mix variation."[4] Martin Feldstein was one of the first researchers in the health field to adjust for case-mix in an attempt to more clearly define hospital output. In his 1960 study sample of 177 acute non-teaching hospitals, the various specialties were grouped into eight mutually-exclusive categories: general medicine; paediatrics; general surgery; ear, nose and throat; traumatic and orthopaedic surgery; other surgery; gynaecology and obstetrics. A ninth category comprising less than ten percent of all cases was considered as a residual. The proportion of cases within each category was then calculated.[1, 2] He concludes "that when the case-mixes of large, acute hospitals are represented by nine broad specialty categories there is a high degree of interhospital variation."[3]

---

[1] Feldstein, Economic Analysis for Health Service Efficiency, p. 25.

[2] Greenfield, p. 21.

[3] Berki, p. 31.

[2] Ibid., p. 34.

In a study of 5,293 non-federal short-term general and other special hospitals in the United States Berry, using 1963 data from the American Hospital Association, grouped hospitals with similar facilities and services. He determined forty groups of hospitals, the largest group containing 92 hospitals. On this basis he analyzed cost-output relationships, assuming that the product variation would exert a minimum influence on the relationship between cost and the level of output for these hospitals.[4]

A similar approach was taken by Francisco, in a study of 4,710 short-term general hospitals. Sixteen hospital facilities and services were identified, and hospitals were grouped according to identical combinations of facilities and services. In the regression analyses, only the combinations with thirty or more hospitals were considered. The final number of groups was twenty-five, which included 1,328

---

[1] Feldstein, Economic Analysis for Health Service Efficiency, p. 15.

[2] "Hospitals are required to present annual reports of the number of cases treated in each specialty." Ibid., p. 15.

[3] Ibid., p. 21.

[4] Berry, pp. 134-136.

hospitals from the original sample.[1]

Lave and Lave, in studying cost functions for 74 Western Pennsylvania hospitals on data obtained for the years 1961-67, recognized the problem of the multi-product nature of output and the variation in output mix among hospitals. To overcome this difficulty, they made the assumption that output mix is constant within a given hospital over a short period of time. Instead of comparing hospitals of various sizes, they studied individual hospitals. With a number of observations on each hospital over a period of a few years, estimated cost-output relationships were obtained.[2] "This approach to the problem eliminates the difficulty in having to define the nature and make-up of the products offered by each hospital."[3] In making the assumption that a hospital's output mix is constant, the authors in fact negate the importance of including a measure of case-mix in their analyses. Moreover, this assumption would be valid only if exhaustive studies to determine the actual output mix were done over a period of time. Further, it would be tenuous to generalize the findings beyond each individual hospital studied, therefore, any attempt to compare inter-hospital cost behaviour on the basis of output mix would be unreliable.

In a more recent study of 65 Western Pennsylvania hospitals by Lave and Lave, five measures were constructed to describe in-patients on the basis of diagnoses and surgical procedures.[1] The study time period was from 1965 to 1968. The purpose of the study was to determine how much case-mix varies across different types of hospitals. Seventeen broad International Classification of Diseases - Adapted (ICDA) groupings and the percentage of patients and patient days were computed, and the variations in these measures across hospitals were analyzed. Their results showed that the extent of variation in case-mix within hospitals over time was less than between hospitals.[2]

---

[1] Edgar W. Francisco, "Analysis of Cost Variations Among Short-Term General Hospitals," in Empirical Studies in Health Economics, ed. by A.E. Klarman (Baltimore: Johns Hopkins Press, 1970), pp. 322-323.

[2] Lave and Lave, pp. 380-382.

[3] Migue and Belanger, p. 38.

✓

Evans repeated the approach used by M. Feldstein in a study of 186 acute-care hospitals in Ontario. Data based on 1967 discharge forms completed for each patient and discharge diagnoses according to the ICDA classifications were used.[3] The diagnoses were grouped into 41 categories, and the age-sex data were grouped into forty categories. The proportion of in-patients was then determined for each category. Average cost functions were then estimated for average cost per case and average cost per day. He concluded that "the diagnostic mix of a hospital's patient-load is an extremely important determinant of the hospital's in-patient expense patterns."[4]

Evans and Walker replicated the Ontario study to a large extent in British Columbia, using ninety active treatment hospitals. They conclude that discharge diagnoses are of crucial importance in determining variations between hospitals in cost per case and cost per day.[1]

---

[1] Judith R. Lave and Lester B. Lave, "The Extent of Role Differentiation Among Hospitals," Health Services Research 6 (Spring, 1971): 15

[2] Ibid., p. 28.

[3] Evans, p. 202.

[4] Ibid., p. 210.

The hospital may be viewed as a multi-product firm, and therefore output identification in the absence of a common denominator has been a difficult task for researchers in the hospital system. Recognizing the severe limitations in cost-output relationships in hospital cost studies due to a lack of standardization of product-mixes, several recent investigators have made attempts at correcting this shortcoming, by controlling for case-mix variations within hospitals. The most promising approaches in endeavoring to eliminate the influence of product heterogeneity have been studies carried out by Martin Feldstein,[2] and Evans.[3]

Few researchers in the hospital system have restricted their studies to short-run cost-output relationships. More commonly, analyses involving long-run estimations have been included.[4] For purposes of this study, however, the survey of selected studies in general public hospitals has been limited to short-run analyses and findings.

Empirical Short-Run Cost Studies in General Hospitals: A Summary Overview

An overview of parameters and results obtained in cost-output studies conducted in the hospital sub-sector of the health care field is presented in table 1.[1] A review of this table reveals the lack of consistency in studies with respect to the measurement of cost functions and hospital output indices, and therefore inconclusive comparison of results across studies.

---

[1] Evans and Walker, p. 417.

[2] Feldstein, Economic Analysis for Health Service Efficiency, pp. 1-303.

[3] Evans, pp. 198-213.

[4] For an explanation of cost behaviour in the long-run, see Leftwich, p. 159.

Summary of the Literature Review

This review of selected literature has been concerned with the general theoretical background of cost functions (total costs and average costs) in the short-run, and an overview of the major empirical studies carried out both in industry, and the hospital sector of the health care field in the short-run. The existing literature related to the behaviour of cost functions in the hospital system is limited. Unlike other production firms, the hospital is not considered in terms of profit maximization, but rather as a producing unit whose primary function is that of providing patient care through many hospital departments, each of which has its own set of outputs or services. Thus the overall hospital's objective is complex. The heterogeneous nature of the hospital sector, and the diversity among hospitals in terms of cost specifications, and measurement of the hospital's products or output, have posed special analytical problems for researchers in the hospital field.

The analytical framework for examining hospital cost function behaviour has not been consistent in the literature. Some of the outstanding measurement difficulties, namely those dealing with cost

---

[1] The sources of all studies presented are previously cited in pp. 3-32.

TABLE 1

TABULAR REVIEW OF SELECTED LITERATURE ON SHORT-RUN COST FUNCTIONS

Author	Year of Publication	Study Data	No. of Hospitals	Hospital Size Range (No. of Beds)	Cost Specifications	Output Measures	Nature of Study	Method of Analysis	Conclusions
P. Feldstein	1961	Monthly data for 2 years	1	242	1.Departmental costs adjusted for price and wage rate changes 2.Total costs	No.of adult patient days	Time-series	Least squares regression (linear)	Most costs did not vary with changes in the number of patient days
R. Berry	1967	1963	5,293 reduced to 40 groups homogenous as to services & facilities	Not Stated	Average costs	1.Patient day 2.Total patient days	Cross-sectional	Least squares regression (linear)	In 36 of 40 estimates, a negative correlation existed between average costs and patient days. Average cost curves declined as the output increases.
E. Francisco	1970	1966	1.4,710 reduced to 1,328 consisting if 25 groups homogenous with respect to a combination of facilities. 2.4,710 reduced to 1,328 consisting of 17 groups homogenous with regard to only the number of services and facilities	Not Stated	1.Total costs 2.Average costs	Total patient days	Cross-sectional	Least squares regression 1.Simple linear and curvilinear for each group	1.Total cost-output relationship is best explained by a second degree or third degree curve for 7 of 25 groups. Remaining 188 groups have coefficients not significantly different from zero. 2.Average cost is less for the large hospitals in each group. 15 of the 17 groups show decreasing average cost. Of the 9 groups with 135 beds (average) or less, 7 show significantly decreasing costs. Of the 8 groups (average), only one shows significantly decreasing average costs. Average cost curves are U-shaped.

TABLE 1 (continued)

Author	Year of Publication	Study Data	No. of Hospitals	Hospital Size Range (No. of Beds)	Cost Specifications	Output Measures	Nature of Study	Method of Analysis	Conclusions
M. Feldstein	1968	1960-61	1. 177 grouped according to case-mix into 9 categories 2. 177 grouped according to case-mix and stratified according to size	1. 72 - 1064 2. 72 - 1064 -two groups, one above and one below the mean -four groups with divisions at one standard deviation	1.Average costs 2.Average costs	1.Case-flow rate 2.Patient week	Cross-sectional (hospital size constant)	Least squares regression 1.Linear 2.Quadratic	1.Short-run cost function decreasing throughout most of observed range of case-flow values. 2.Average hospital is operating on the rising section of the cost per week curve. Cost per week rises less rapidly as case-flow increases in smaller hospitals than in larger ones. Cost per case would fall substantially if case-flow increased.
R.D. Fraser	1971	1966	848 stratified into 9 groups according to hospital size and classified according to Province	Not Stated	3 measures of total cost	Measure of composite output (obtained by summing the weighted quantities of 13 different hospital services.	Cross-sectional	Least squares regression linear, quadratic	Total operating costs were rising at a decreasing rate for almost every size hospital in Canada.
R.G. Evans	1971	1967	186(Ontario) adjusted for out-put mix & including a measure of hospital scale (total rated beds)	Not Stated	Average costs less expenses on education research & out-patient care, depreciation, interest and capital costs	Number of patient days Number of separations (discharges or deaths) Average occupancy rates Average lengths of stay.	Cross-sectional	Least squares regression	Mix of diagnoses explained about 80 percent of inter-hopsital variance in cost per case and 50 pe percent of variance in cost per day The occupancy rate had a small but significant impact on both costs. The average length of stay was strongly positive and significant for cost per case, and relatively insignificant in explaining cost per day. Results confirm usefulness of using cost per case as output measure.

TABLE 1 (continued)

Author	Year of Publication	Study Data	No. of Hospitals	Hospital Size Range (No. of Beds)	Cost Specifications	Output Measures	Nature of Study	Method of Analysis	Conclusions
Lave & Lave	1970	1961-67	74 assuming product mix for each hospital remained constant	Not Stated	Average cost for each hospital	Patient-day	Time-series a number of observations on each hospital over time	Least squares regression	Results inconclusive, however suggest that the short-run average cost curve is L-shaped.

measurements, output measurements, and the measurement of homogeneous products were reviewed in this chapter.

This study was designed to provide a more specific basis upon which to analyze selected cost functions and output in general public hospitals in the short-run. The methodology and empirical findings are described in the following chapter.

CHAPTER III

ECONOMETRIC ANALYSIS OF SHORT-RUN AVERAGE COSTS BY HOSPITAL SIZE CLASSES

Introduction

The purpose of this chapter is to present the results obtained from an empirical investigation into the effect of variations in case-flow and plant capacity on three specific types of short-run hospital costs, namely, (1) average general administration costs, (2) average nursing administration costs, and (3) average nursing service costs. Ordinary least squares regression analysis,[1] and analysis of covariance[2] were the models utilized in carrying out the investigation.

This chapter is organized in the following manner: firstly there are four sections. Sections I, II, and III deal with each of the three general cost relationships. Each of the three sections contains two parts. Part 1 sets out the general economic relationship between the average costs and case-flow. Three types of functions: linear; quadratic; and the inverse form are estimated, and the empirical results are presented. Part 2 consists of an investigation of the effect that variations in the size of hospital capacity within each size class would have on average costs. This analysis requires the addition of the plant capacity term into each of the three types of functions. The empirical results are presented for each average cost.

---

[1] There are a large number of standard expositions of ordinary least squares techniques applied in the field of economics. The interested reader may refer to Ronald J. Wonnacott and Thomas H. Wonnacott, Econometrics (New York: John Wiley and Sons Inc., 1970), pp. 54-58.

[2] Refer to J. Johnston, Econometric Methods, 2nd ed. (New York: McGraw-Hill Book Company, 1972), pp. 192-297.

Section IV contains the analysis of co-variance results. The purpose of this section is to determine whether the a priori classification of hospitals by size class laid down by the Alberta Hospital Services Commission, and by the Department of National Health and Welfare is substantiated by statistically significant differences in the specific form of the econometric equations estimated for each hospital class. The investigation was restricted to the linear form of the equation.

Data

The data for this section are based on 108 General Public Hospitals in Alberta for 1971. The total sample of 115 hospitals was subdivided into five groups according to size classes determined by rated bed capacity.[1] These subdivisions were previously defined by the Alberta Hospital Services Commission[2] and are depicted in table 2. There is no economic basis for the categorization of these hospitals in this manner. The rationale for the size categorization is that (1) it is consistent with the breakdown of hospitals into size classes with that used by the Federal Government for reporting purposes; and (2) there is a distinct difference between the size classes (particularly for the 1-24 and 25-49 groups in terms of level of activity expected which is based on medical manpower in the communities concerned.[1]

---

[1] Appendix A lists the study hospitals with corresponding rated bed capacities according to size classes.

[2] 1971 Financial and Statistical Tables for Alberta Hospitals, pp. 1-4.

TABLE 2

NUMBER OF HOSPITALS IN SIZE CLASSES AND PERCENTAGE OF TOTAL - ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Hospital Size Class (Number of Beds)	Number of Hospitals	Percentage of Total
1 - 24	22	19.1
25 - 49	47	40.9
50 - 99	29	25.2
100 - 299	10	8.7
300 +	7	6.1
Total	115	100.0

Table 3 consists of descriptive statistics for the five variables under consideration. For definitions of these variables, refer to chapter I, this study.

Section I: The Analysis of Average General Administration Cost Relationships

Part 1: Average General Administration Costs and Case-Flow

On a priori grounds, total administration costs are fixed in the short-run. They do not vary with output, as noted in chapter II. Salaries and wages of top management represent the largest proportion

---

[1] Interview with Mrs. Fernande Harrison, Health Services Administrator, Alberta Hospital Services Commission, 15 October 1974.

TABLE 3

DESCRIPTIVE STATISTICS BY HOSPITAL SIZE CLASS, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

VARIABLE	1-24 Beds			25-49 Beds			50-99 Beds			100-299 Beds			300^+ Beds		
	N=22			N=47			N=29			N=10			N=7		
Number of Hospital Beds	Mean 16.6	Med. 16.5	S.D. 5.0	Mean 32.5	Med. 31	S.D. 5.9	Mean 60.8	Med. 58.5	S.D. 10.2	Mean 164.9	Med. 164.5	S.D. 53.3	Mean 764.1	Med. 759.8	S.D. 237.8
	Rge. 17	Min. 7	Max. 24	Rge. 22	Min. 25	Max. 47	Rge. 30	Min. 50	Max. 80	Rge. 130	Min. 100	Max. 230	Rge. 555	Min. 513	Max. 1068
Case-Flow	Mean 30.2	Med. 28.9	S.D. 10.0	Mean 37.0	Med. 36.5	S.D. 11.0	Mean 33.3	Med. 33.4	S.D. 7.8	Mean 34.7	Med. 34.8	S.D. 5.6	Mean 29.4	Med. 29.0	S.D. 4.8
	Rge. 32.8	Min. 10.9	Max. 43.7	Rge. 56.4	Min. 8.8	Max. 65.2	Rge. 27.6	Min. 22.4	Max. 49.9	Rge. 19.4	Min. 24.8	Max. 44.2	Rge. 13.8	Min. 24.3	Max. 38.1
Average General Administration Cost	Mean 40	Med. 34	S.D. 21	Mean 41	Med. 33	S.D. 23	Mean 47	Med. 42	S.D. 20	Mean 55	Med. 48	S.D. 23	Mean 87	Med. 85	S.D. 25
	Rge. 74	Min. 15	Max. 88	Rge. 107	Min. 19	Max. 127	Rge. 85	Min. 20	Max. 105	Rge. 83	Min. 35	Max. 118	Rge. 69	Min. 62	Max. 131
Average Nursing Administration Cost	Mean 12	Med. 10	S.D. 8	Mean 7	Med. 7	S.D. 4	Mean 7	Med. 5	S.D. 5	Mean 12	Med. 12	S.D. 4	Mean 8	Med. 8	S.D. 4
	Rge. 30	Min. 3	Max. 32	Rge. 25	Min. 2	Max. 27	Rge. 24	Min. 3	Max. 27	Rge. 13	Min. 6	Max. 19	Rge. 11	Min. 4	Max. 15
Average Nursing Service Cost	Mean 161	Med. 149	S.D. 56	Mean 124	Med. 119	S.D. 32	Mean 146	Med. 144	S.D. 32	Mean 185	Med. 192	S.D. 22	Mean 265	Med. 258	S.D. 43
	Rge. 230	Min. 104	Max. 334	Rge. 206	Min. 79	Max. 285	Rge. 134	Min. 99	Max. 234	Rge. 67	Min. 155	Max. 223	Rge. 133	Min. 218	Max. 351

Note: Med. = Median
S.D. = Standard Deviation
Rge. = Range

of general administration costs[1] and are not affected by any variation in output in the short-run.[2] As detailed in chapter I, p. 8, these costs are exclusive of nursing administration costs. Based upon this assumption, an average fixed cost function should have the form of a rectangular hyperbola;[3] however, if administration inputs are considered to be variable by hospital management, then other average cost functions are suitable, namely linear and quadratic forms. The basic specifications are as follows:

Linear (I-1) $C = \alpha_0 + \alpha_1 F + \epsilon_i$

where C represents average general administration cost per case; F represents case-flow, and ϵ_i represents the stochastic or error term.

Quadratic (I-2) $C = \alpha_0 + \alpha_1 F + \alpha_2 F^2 + \epsilon_i$

Inverse Form (I-3) $C = \alpha_0 + \alpha_1 F^{-1} + \epsilon_i$

Regression Results

As there were too few hospitals with 300 beds and over for statistical interpretation, no analyses were done on this group.

The following regression results provide estimates of short-run average cost curves in the 1-24 bed size range, and illustrate in detail the analyses carried out on the three remaining size classes.

---

[1] Riley, pp. 38-39.

[2] Mansfield, p. 160.

[3] Ibid., pp. 163-165.

Linear Form

(I-4) $\hat{C} = 91.7 - 1.71F$

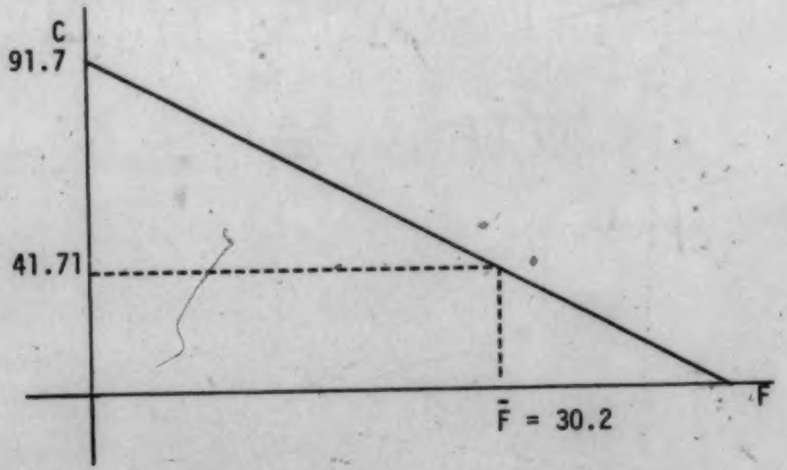
$(8.71)\ (.274)$

$t = 10.53^{*}\ t = -6.25^{*}$

$R^2 = 0.66$

*Significant at $\alpha = 0.05$; $\alpha = 0.01$

These estimations indicate that for the linear regression form, both the intercept term and the F term are statistically significant at the five percent and one percent levels of significance. For every increase in case-flow, there would be a reduction in the general administration cost per case. The R^2 value suggests a reasonably good fit for cross-sectional data.



In reference to the above sketch, the average case-flow rate for hospitals in the 1-24 hospital size class is 30.2, with an average general administration cost of $40.00 (see table 3, p. 41). This equation estimates the average cost at $41.71. As the level of output increases, there would be a reduction of $1.71 in average cost.

U-shaped Form

(I-5) $$\hat{C} = 90.1 - 1.57F - 3.0\text{x}10^{-5}F^2$$

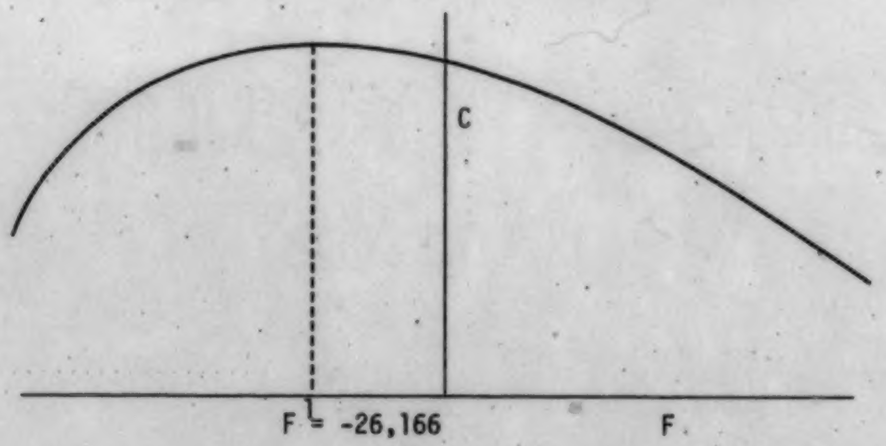
$$(10.3) \quad (.537) \quad (9.0\text{x}10^{-5})$$

$$t = 8.71^* \quad t = 2.93^* \quad t = -0.31$$

$$R^2 = 0.66$$

*Significant at $\alpha = 0.50$; $\alpha = 0.01$

The results for the quadratic equation show that both the intercept term and the F term are significant at the five percent and one percent levels of significance; however, the squared term is not significant at either level. The R^2 value suggests a good fit.



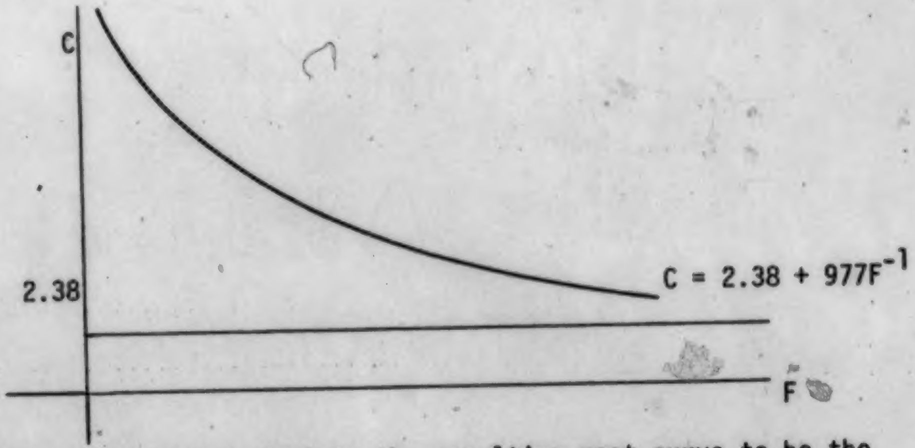
The sketch depicts that the relevant arm of the quadratic function is in the positive quadrant. The U is inverted, and the turning point is clearly an artifact. Since F^1 is the point where $\frac{\partial^2 C}{\partial F^2} < 0$ and $F^1 = -26,166$, it is beyond any practical value.

Inverse Form

(I-6)
$$
\begin{array}{ll}
\hat{C} = 2.38 + & 977F^{-1} \\
\quad (5.68) & (133.9) \\
t = 0.419 & t = 7.29^{*} \\
 & R^{2} = 0.73
\end{array}
$$

*Significant at $\alpha = 0.05$; $\alpha = 0.01$

The intercept term is not statistically significant, however, the regression coefficient on F is significant at both the five percent and one percent levels.



The above sketch depicts the resulting cost curve to be the shape of a rectangular hyperbola, given the low "t" value for the intercept term. The average general administration cost declines with an increase in the case-flow rate. The actual mean case-flow rate is 30.2.

The three regression equations illustrated suggest reasonably good fits, or approximations. Comparing these, it is noted that although the R^2 values are approximately the same, the inverse form does provide a marginally better fit (i.e., it makes the total error the least) and supports the theory of average cost function behaviour (chapter II, p. 16). The objective, however, was not to maximize the value of R^2. The point to note is that empirical estimates between administrative costs and output confirm the a priori hypothesis with respect to fixed costs. The fact that an increase in case-flow would tend to lower costs supports the standard relationship in reducing overhead costs. Thus, potential administrative economies do exist from expanding output expressed as case-flow rates.

Overall Results

Table 4 provides an overview of the estimated relationships for all of the size classes. An examination of the table reveals that the general observations regarding hospitals in the 1-24 bed size class hold across the remaining classifications, i.e., an average fixed cost curve which has the shape of a rectangular hyperbola is almost as good or a better fit than those obtained from quadratic or linear models which is in keeping with theoretical expectations. Total administration costs are invariant with respect to output, and it follows that average fixed costs should approximate the shape of a rectangular hyperbola. It should be noted, however, that on econometric grounds there is little practical basis on which to choose among the three specifications.

Part 2: The Effect of Interclass Hospital Size Variations on Average General Administration Cost Relationships

It was assumed that hospital size had no effect on costs in the short-run; however, there are substantial variations in plant capacity within each of the hospital size groupings. In effect, the proportion of variation in the average general administration cost within each category could be explained by variation in bed capacity as well as by variation in case-flow. Feldstein alludes to the fact that "hospital

TABLE 4

ESTIMATED RELATIONSHIPS BETWEEN AVERAGE GENERAL ADMINISTRATION COSTS AND CASE-FLOW BY HOSPITAL SIZE, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Specification	$\hat{C}= \hat{\alpha}_0 + \hat{\alpha}_1F$	$\hat{C}= \hat{\alpha}_0 + \hat{\alpha}_1F + \hat{\alpha}_2F^2$	$\hat{\hat{C}}= \hat{\alpha}_0 + \hat{\alpha}_1F^{-1}$
1-24 Beds	$\hat{C} = 91.7 \quad - 1.71F$ $(8.71) \quad (.274)$ $t=10.53^* \quad -6.25^*$ $R^2=0.66$	$\hat{C} = 90.1 \quad - 1.57F \quad - 3.0\times10^{-5}F^2$ $(10.3) \quad (.537) \quad (9.0\times10^{-5})$ $t=8.71^* \quad -2.93^* \quad -0.31$ $R^2=0.66$	$\hat{C} = 2.38 \quad + 977.0F^{-1}$ $(5.68) \quad (133.9)$ $t=0.419 \quad 7.29^*$ $R^2=0.73$
25-49 Beds	$\hat{C} = 90.3 \quad - 1.34F$ $(9.50) \quad (.246)$ $t=9.51^* \quad -5.44^*$ $R^2=0.40$	$\hat{C} = 131.2 \quad - 3.72F \quad + 3.1\times10^{-4}F^2$ $(17.3) \quad (.897) \quad (1.1\times10^{-4})$ $t=7.57^* \quad -4.15^* \quad 2.75^*$ $R^2=0.49$	$\hat{C} = 10.0 \quad + 1007.9F^{-1}$ $(5.93) \quad (174.6)$ $t=1.69 \quad 5.77^*$ $R^2=0.43$
50-99 Beds	$\hat{C} = 105.1 \quad - 1.76F$ $(12.8) \quad (.373)$ $t=8.24^* \quad -4.71^*$ $R^2=0.45$	$\hat{C} = 170.2 \quad - 5.76F \quad + 5.8\times10^{-4}F^2$ $(48.7) \quad (2.92) \quad (4.2\times10^{-4})$ $t=3.50^* \quad -1.98 \quad 1.38$ $R^2=0.49$	$\hat{C} = 12.9 \quad + 1880.9F^{-1}$ $(12.6) \quad (390.1)$ $t=-1.02 \quad 4.82^*$ $R^2=0.46$
100-299 Beds	$\hat{C} = 154.4 \quad - 2.87F$ $(37.5) \quad (1.07)$ $t=4.12^* \quad -2.69^*$ $R^2=0.47$	$\hat{C} = 254.6 \quad - 8.54F \quad + 8.0\times10^{-4}F^2$ $(78.4) \quad (4.09) \quad (5.6\times10^{-4})$ $t=3.25^* \quad -2.09 \quad 1.43$ $R^2=0.59$	$\hat{C} = 52.0 \quad + 3620.3F^{-1}$ $(31.3) \quad (1047.7)$ $t=-1.66 \quad 3.46^*$ $R^2=0.60$

*Significant at $\alpha = 0.05$

size does influence the intensity with which hospital capacity is used."[1] The results of regression analyses including a measure of hospital size in his study, however, show that a measure of hospital size in the short-run function does not substantially affect the shape of the cost curves.[2]

In order to investigate the possibility of hospital size influencing the estimated relationships between average general administration costs and case-flow within size classes, the following additions to the basic specifications were made.

Specifications:

Linear (I-7)	$C = \alpha_0 + \alpha_1 F + \alpha_2 B + \epsilon_i$
	where B refers to the number of hospital beds.
Quadratic (I-8)	$C = \alpha_0 + \alpha_1 F + \alpha_2 F^2 + \alpha_3 B + \alpha_4 B^2 + \epsilon_i$
Inverse Form (I-9)	$C = \alpha_0 + \alpha_1 F^{-1} + \alpha_2 B + \epsilon_i$

Regression Results

The results obtained from these specifications are set out in table 5. In all instances, the coefficients for hospital size were insignificant in terms of the t values, and the R^2 values were not increased in any significant manner. It is interesting to note that the addition of a plant scale measure to the linear equations tends to reduce costs, although by an inconsequential amount from a practical

---

[1] Feldstein, Economic Analysis for Health Service Efficiency, p. 131.

[2] Ibid., p. 64.

TABLE 5

ESTIMATED RELATIONSHIPS BETWEEN AVERAGE GENERAL ADMINISTRATION COSTS AND CASE-FLOW AND HOSPITAL SIZE, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Specification	$\hat{C}=\alpha_0+\alpha_1F+\alpha_2B$	$\hat{C}=\alpha_0+\alpha_1F+\alpha_2F^2+\alpha_3B+\alpha_4B^2$	$\hat{C}=\alpha_0+\alpha_1F^{-1}+\alpha_2B$
1-24 Beds	$\hat{C}=98.8 - 1.76F - .346B$ $(14.8)\ (.289)\ (.575)$ $t=6.67^*\ -6.09^*\ -0.602$ $R^2=0.67$	$\hat{C}=52.0 - 1.35F - 5.0\times10^{-5}F^2 + 5.08B - 1.69\times10^{-3}B^2$ $(40.2)\ (.645)\ (1.0\times10^{-4})\ (4.32)\ (1.34\times10^{-3})$ $t=1.29\ -2.09\ -0.516\ 1.174\ -1.26$ $R^2=0.70$	$\hat{C}=4.56 + 985.6F^{-1} + .151B$ $(9.40)\ (140.2)\ (.512)$ $t=.486\ 7.03^*\ -0.30$ $R^2=0.73$
25-49 Beds	$\hat{C}=80.0 - 1.36F + .338B$ $(17.1)\ (.249)\ (.464)$ $t=4.68^*\ -5.46^*\ 0.73$ $R^2=0.40$	$\hat{C}=63.4 - 3.50F + 2.9\times10^{-4}F^2 + 3.58B - 4.8\times10^{-4}B^2$ $(82.7)\ (.943)\ (1.2\times10^{-4})\ (1.44)\ (6.3\times10^{-4})$ $t=0.766\ -3.71^*\ 2.38^*\ 0.807\ -0.761$ $R^2=0.50$	$\hat{C}=2.71 + 1012.2F^{-1} + .221B$ $(16.1)\ (176.4)\ (.453)$ $t=0.168\ 5.74^*\ .488$ $R^2=0.43$
50-99 Beds	$\hat{C}=95.7 - 1.73F + .140B$ $(23.6)\ (.383)\ (.294)$ $t=4.05^*\ -4.52^*\ 0.477$ $R^2=0.46$	$\hat{C}=177.3 - 6.35 + 6.8\times10^{-4}F^2 + .186B + 3.0\times10^{-5}B^2$ $(163.4)\ (3.10)\ (4.5\times10^{-4})\ (4.82)\ (3.8\times10^{-4})$ $t=1.08\ -2.05\ 1.51\ -0.038\ 0.090$ $R^2=0.50$	$\hat{C}=-23.5 + 1852.2F^{-1} + .189B$ $(20.6)\ (396.7)\ (.288)$ $t=-1.14\ 4.67^*\ 0.657$ $R^2=0.47$
100-299 Beds	$\hat{C}=167.9 - 2.87F - 8.2\times10^{-2}B$ $(43.2)\ (1.10)\ (.117)$ $t=3.89^*\ -2.60^*\ -0.704$ $R^2=0.51$	$\hat{C}=238.9 - 6.61F + 5.3\times10^{-4}F^2 - 7.56\times10^{-2}B - 1.0\times10^{-5}B^2$ $(103.4)\ (7.16)\ (1.0\times10^{-3})\ (.224)\ (1.0\times10^{-5})$ $t=2.31\ -0.923\ 0.529\ -0.337\ -0.589$ $R^2=0.62$	$\hat{C}=-45.5 + 3570.6F^{-1} - .031B$ $(40.2)\ (1126.7)\ (.106)$ $t=-1.13\ 3.17^*\ -0.288$ $R^2=0.60$

*Significant at $\alpha=0.05$

stance. For example, in the 1-24 bed size class, the unit cost is reduced by $0.05. In reference to the quadratic equations, with the exception of the 50-99 bed group, unit costs are noted to increase slightly, the greatest increase estimated for the 100-299 bed group, at $1.93 per case.

With respect to the inverse form of the equation, the coefficients are little influenced with the inclusion of a scale term.

In sum, the findings suggest that average general administration costs fit within the theoretical expectations and concur with the empirical findings of Feldstein.[1]

Section II: The Analysis of Average Nursing Administration Cost Relationships

Part 1: Average Nursing Administration Costs and Case-Flow

As discussed in chapter I, p. 9, nursing administration costs are not included in general administration costs. On the basis of theory, it is hypothesized that nursing administration costs would behave in a similar manner to general administration costs, that is, as fixed costs mathematically represented in inverse functions (chapter II, p. 13).

The basic specifications set out in I-1 to I-3 are followed in providing estimates for average nursing administration costs.

Regression Results

Three examples of estimated relationships and corresponding cost curves for nursing administration based on the above specifications are depicted for hospitals ranging in capacity from 50 to 99 beds.

---

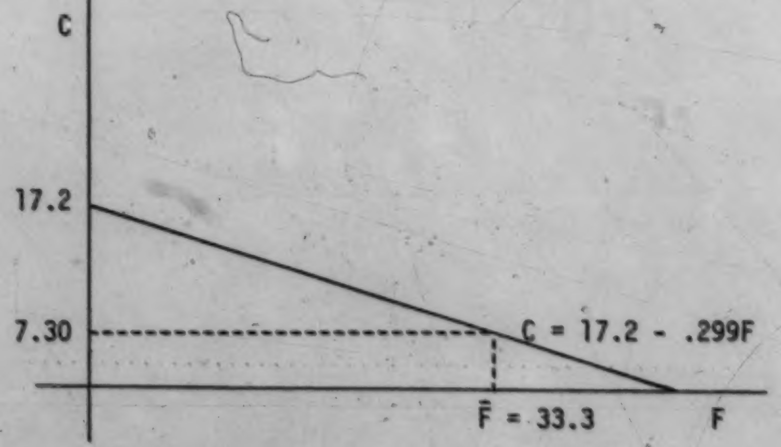
[1] Feldstein, Economic Analysis for Health Service Efficiency, p. 131.

$$\begin{array}{lll} \text{Linear Form} & \hat{C} = 17.2 \; - & .299F \\ \text{(I-10)} & \quad (3.75) & (.110) \\ & t = 4.59^{**} & t = -2.73^{*} \\ & & R^2 = 0.22 \end{array}$$

*Significant at $\alpha = 0.05$

**Significant at $\alpha = 0.01$

In the above regression equation, both the intercept term and the regression coefficient of F are statistically significant at the five percent level of significance; however, only the intercept term is significant at the one percent level. For every unit increase in case-flow, average nursing administration costs are estimated to decrease by $0.30.



The actual mean case-flow rate for hospitals in the 50-99 beds is 33.3 with a mean cost per case of $7.00. The above sketch predicts the mean cost at $7.30.

U-Shaped Form

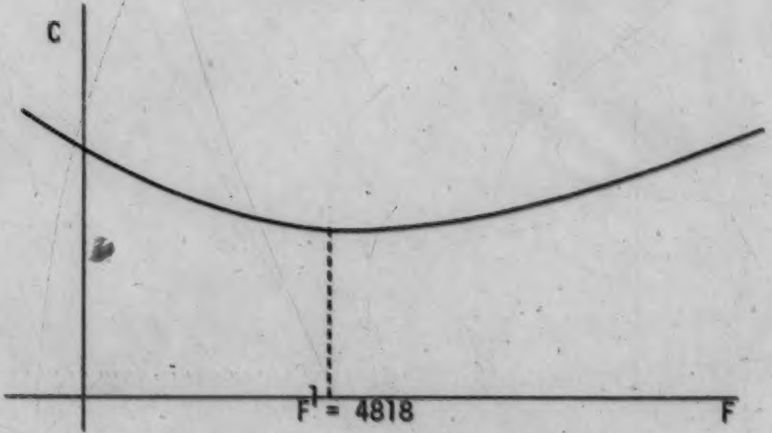
(I-11) $$\hat{C} = 29.6 - 1.06F + 1.1\text{x}10^{-4}F^2$$

$$(14.6) \quad (.875) \quad (1.3\text{x}10^{-4})$$

$$t = 2.03^{*} \quad t = -1.21 \quad t = 0.879$$

$$R^2 = 0.24$$

*Significant at $\alpha = 0.05$



In reference to the above sketch, the estimated optimal case-flow rate ($F^1 = 4818$) is well beyond any practical meaning in the positive quadrant of the u-shaped curve. Cost per case is noted to decrease with each increase in case-flow throughout the relevant range.

Inverse Form

(I-12) $$\hat{C} = -3.19 + 330.2F^{-1}$$

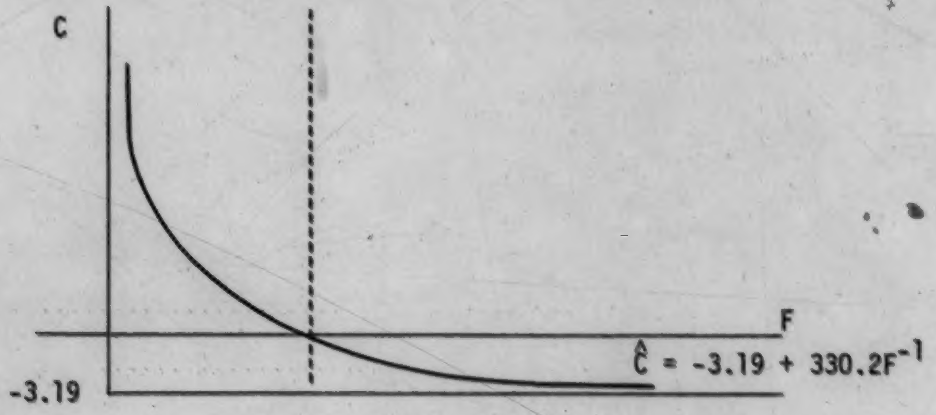
$$(3.70) \quad (114.3)$$

$$t = -0.861 \quad t = 2.89^{*}$$

$$R^2 = 0.24$$

*Significant at $\alpha = 0.05$

Observation of the above equation depicts that the intercept term has no statistical significance whereas the regression coefficient on F is statistically significant at the five percent level.



The only relevant portion is in the positive quadrant of the cost curve, as illustrated in the above graph. The intercept term is a negative quantity, and does not have any practical meaning.

Comparing the three estimated relationships, it is observed that there is no difference in the R^2 values for the quadratic and inverse equations, which have marginally higher values than for the linear model.

Table 6 presents the complete set of estimated relationships between average nursing administration costs and case-flow for all size classes under consideration. It is noted that except for the 50-99 bed group, where there is no difference in the R^2 values for the quadratic and inverse form of the equation, the inverse form of the equation provides the best fit for all groups. On the basis of these results, it can be concluded that nursing administration cost curves tend to have the shape of rectangular hyperbolas.

The linear equations show that, as the case-flow increases, costs decrease. Similarly, this principle applies to the quadratic equations,

TABLE 6

ESTIMATED RELATIONSHIPS BETWEEN AVERAGE NURSING ADMINISTRATION COSTS AND CASE-FLOW BY HOSPITAL SIZE, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Specification	$\hat{C}=\hat{\alpha}_0+\hat{\alpha}_1F$	$\hat{C}=\hat{\alpha}_0+\hat{\alpha}_1F+\hat{\alpha}_2F^2$	$\hat{C}=\hat{\alpha}_0+\hat{\alpha}_1F^{-1}$
1-24 Beds	$\hat{C}=21.2 \quad - .313F$ $(4.91) \quad (.154)$ $t=4.33^* \quad -2.03$ $R^2=0.17$	$\hat{C}=19.5 \quad - .160F \quad - 3.0\times10^{-5}F^2$ $(5.79) \quad (.301) \quad (5.04\times10^{-5})$ $t=3.37^* \quad -0.533 \quad -0.597$ $R^2=0.19$	$\hat{C}=1.85 \quad + 258.5F^{-1}$ $(3.05) \quad (71.9)$ $t=0.605 \quad 3.59^*$ $R^2=0.39$
25-49 Beds	$\hat{C}=15.1 \quad - .211F$ $(1.71) \quad (4.43\times10^{-2})$ $t=8.87^* \quad -4.78^*$ $R^2=0.34$	$\hat{C}=22.0 \quad - .612F \quad - 5.0\times10^{-5}F^2$ $(3.15) \quad (.163) \quad (2.0\times10^{-5})$ $t=6.99^* \quad -3.76^* \quad 2.54^*$ $R^2=0.42$	$\hat{C}=1.12 \quad + 203.3F^{-1}$ $(.860) \quad (25.3)$ $t=1.30 \quad 8.04^*$ $R^2=0.59$
50-99 Beds	$\hat{C}=17.2 \quad - .299F$ $(3.75) \quad (.110)$ $t=4.59^* \quad -2.73^*$ $R^2=0.22$	$\hat{C}=29.6 \quad - 1.06F \quad + 1.1\times10^{-4}F^2$ $(14.6) \quad (.875) \quad (1.3\times10^{-4})$ $t=2.03 \quad -1.21 \quad 0.879$ $R^2=0.24$	$\hat{C}=-3.19 \quad + 330.2F^{-1}$ $(3.70) \quad (114.3)$ $t=-0.861 \quad 2.89^*$ $R^2=0.24$
100-299 Beds	$\hat{C}=23.7 \quad - .339F$ $(7.63) \quad (.217)$ $t=3.10^* \quad -1.56$ $R^2=0.23$	$\hat{C}=28.9 \quad - .634F \quad + 4.0\times10^{-5}F^2$ $(18.0) \quad (.941) \quad (1.3\times10^{-4})$ $t=1.60 \quad -0.674 \quad 0.324$ $R^2=0.24$	$\hat{C}=-1.06 \quad + 439.3F^{-1}$ $(6.92) \quad (231.6)$ $t=0.153 \quad 1.90$ $R^2=0.31$

*Significant at $\alpha=0.05$

in which the average costs decrease with an increase in case-flow, up to a certain point. The estimated optimal case-flow rates, however, were found to be beyond any practical value.

Part 2: The Effect of Interclass Hospital Size Variations on Average Nursing Administration Cost Relationships

It was assumed that in the short-run, hospital size within classes would not explain any variation in estimated relationships by virtue of being relatively homogeneous size classes.

As noted previously, it is useful to examine the variation of plant capacity within each size class. The basic specifications used to examine the capacity effects are identical to those set out in I-7 to I-9, except the cost is average nursing administration.

Regression Results

The regression results are presented in table 7. An examination of the table indicates that the R^2 values are only marginally improved over the results depicted in table 6, with the exception of the estimated relationships obtained for hospitals in the 1-24 and 100-299 bed groups.

Considering those hospitals in the 1-24 size class, it is noted that R^2 values increased in all forms of the regression equation; however, the inverse form continues to provide the best fit. The hospital size terms are not statistically significant. Similarly, in the 100-299 size class, improved R^2 values are noted across all equations with the most marked increase seen for the quadratic equation (an increase from $R^2 = 0.24$ to $R^2 = 0.57$). This increase resulted in a change, that is, in the determination of which equation provides the best fit with the

TABLE 7

ESTIMATED RELATIONSHIPS BETWEEN AVERAGE NURSING ADMINISTRATION COSTS AND CASE-FLOW AND HOSPITAL SIZE, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Specification	$\hat{C}=\alpha_0+\alpha_1F+\alpha_2B$	$\hat{C}=\alpha_0+\alpha_1F+\alpha_2F^2+\alpha_3B+\alpha_4B^2$	$\hat{C}=\alpha_0+\alpha_1F^{-1}+\alpha_2B$
1-24 Beds	$\hat{C}=30.5 - .374F - .450B$ $(7.99)\ (.156)\ (.310)$ $t=3.82^{*}\ -2.40^{*}\ -1.45$ $R^2=0.25$	$\hat{C}=48.5 - .463F + 1.0\times10^{-5}F^2 - 2.69\times10^{-3}B + 7.0\times10^{-4}B^2$ $(22.1)\ (.354)\ (6.0\times10^{-5})\ (2.37)\ (7.4\times10^{-4})$ $t=2.20^{*}\ -1.31\ 0.110\ -1.128\ 0.956$ $R^2=0.29$	$\hat{C}=8.56 + 284.7F^{-1} - .466B$ $(4.66)\ (69.5)\ (.254)$ $t=1.84\ 4.10^{*}\ -1.83$ $R^2=0.48$
25-49 Beds	$\hat{C}=17.8 - .207F - 8.75\times10^{-2}B$ $(3.05)(4.44\times10^{-2})(8.29\times10^{-2}$ $t=5.84^{*}\ -4.65^{*}\ -1.06$ $R^2=0.35$	$\hat{C}=23.6 - .622F + 5.0\times10^{-5}F^2 + 1.09\times10^{-2}B - 2.0\times10^{-5}B^2$ $(14.8)\ (.169)\ (2.0\times10^{-5})\ (.796)\ (1.1\times10^{-4})$ $t=1.59\ -3.67^{*}\ 2.55^{*}\ 0.014\ -0.151$ $R^2=0.45$	$\hat{C}=4.40 + 201.3F^{-1} - .099B$ $(2.28)\ (25.0)\ (.064)$ $t=1.93\ 8.07^{*}\ -1.55$ $R^2=0.61$
50-99 Beds	$\hat{C}=12.7 - .286F - 6.65\times10^{-2}B$ $(6.89)\ (.112)\ (8.56\times10^{-2})$ $t=1.85\ -2.56^{*}\ 0.776$ $R^2=0.23$	$\hat{C}=9.54 - 1.21F + 1.4\times10^{-4}F^2 + .634B - 4.0\times10^{-5}B^2$ $(48.6)\ (.920)\ (1.3\times10^{-4})\ (1.43)\ (1.1\times10^{-4})$ $t=0.196\ -1.32\ 1.02\ 0.442\ -0.381$ $R^2=0.27$	$\hat{C}=7.31 + 319.0F^{-1} + .074B$ $(5.99)\ (115.5)\ (.084)$ $t=-1.22\ 2.76^{*}\ 0.877$ $R^2=0.26$
100-299 Beds	$\hat{C}=27.3 - .339F - 2.18\times10^{-2}B$ $(8.58)\ (.219)\ (2.32\times10^{-2})$ $t=3.18^{*}\ -1.55\ -0.941$ $R^2=0.32$	$\hat{C}=11.6 + 1.23F - 2.2\times10^{-4}F^2 - 7.65\times10^{-2}B - 0.0B^2$ $(18.5)\ (1.28)\ (1.8\times10^{-2})\ (4.01\times10^{-2})\ (0.0)$ $t=0.625\ 0.961\ -1.24\ -1.91\ -1.69$ $R^2=0.57$	$\hat{C}=2.31 + 413.5F^{-1} - .016B$ $(8.65)\ (242.3)\ (2.28\times10^{-2})$ $t=0.267\ 1.71\ -0.694$ $R^2=0.35$

*Significant at $\alpha = 0.05$

addition of the hospital size term. Clearly, for the 100-299 size class, the quadratic equation provides the best fit, suggesting that the nursing administration cost curve is no longer a rectangular hyperbola, but a U-shaped curve. The addition of the hospital size term has indeed contributed some explanatory power in cost variability. This is presumably due to the wide range of hospital sizes within this category. It is noted (table 3) that the hospitals in the 100-299 size class range in size from 100 to 230 beds, the widest variation for any group. The fact that the shape of the cost curves for the 1-24, 25-49 and 50-99 bed hospital classes tend to be L-shaped implies that with increases in case-flow, average nursing administration costs initially decline, and subsequently reach a constant level over a certain range. This phenomenon suggests that for hospitals with less than 100 beds, it would be possible to treat more patients in those essentially "rural" hospitals than they actually do, without incurring higher average nursing administration costs. In other words, productivity could be increased without effecting changes in these average costs because the total fixed cost would be spread over more units of output. In the case of hospitals ranging in size from 100 to 299 beds, empirical results suggest that average costs decline with increases in output, reach a minimum, and then begin to rise with a greater case-flow rate. It is conceivable that as hospital size reaches 100 beds and beyond, the upper limit on the availability of nursing administration input becomes effective at a certain output level, which results in higher nursing administration costs per case. Also, in larger hospitals, there would be a higher ratio of part-time to fulltime staff, and a higher ratio of staff separations which would result in more paper work, and therefore higher average administration costs. In this situation, the cost increases exceed the production increases.

Section III: The Analysis of Average Nursing Service Cost Relationships

Part 1: Average Nursing Service Costs and Case-Flow

Although total nursing service costs include total nursing administration costs, as discussed in chapter I, p. 9, it would seem reasonable to expect that total nursing service costs would tend to behave more as variable than fixed costs. The rationale for this assumption is the inclusion of the cost of medical and surgical supplies and drugs in the total cost, which are highly variable components, and a relatively variable nursing labour situation. Total nursing administration costs which are fixed costs represent only a small proportion of total nursing service costs. Similarly, average nursing service costs would be expected to have the traditional U-shaped curves for total average costs.

The basic specifications previously set out in I-1 to I-3 are followed in providing estimates of short-run average cost curves for nursing service.

Regression Results

The following three regression equations and corresponding average nursing service cost curves, based on the above specifications, are for hospitals in the 100-299 size class.

Linear Form

(I-13)

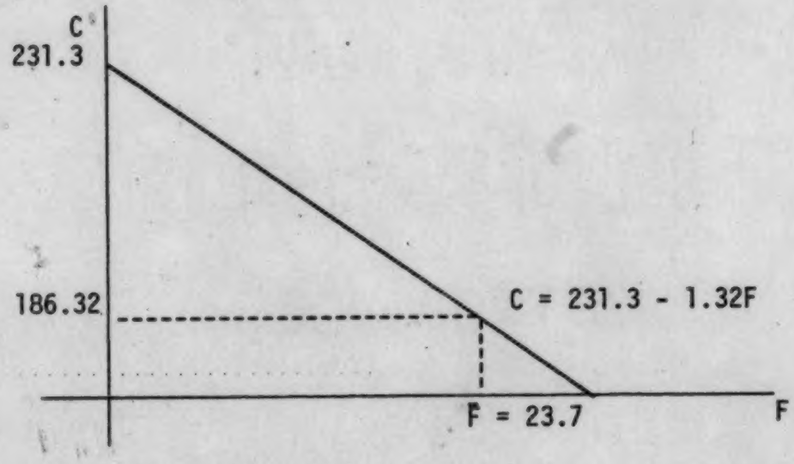
$$\hat{C} = \underset{(46.9)}{231.3} - \underset{(1.33)}{1.32}F$$

$$t = 4.94^{*} \quad t = 0.992$$

$$R^2 = 0.11$$

*Significant at $\alpha = 0.05$; $\alpha = 0.01$

In reference to the above equation, the intercept term is statistically significant at the five percent and one percent levels of significance, whereas the slope coefficient is not significant at either level. The R^2 value is extremely low.



The average case-flow rate for hospitals in the 100-299 size class is 34.7, with an average nursing service cost of $185.00. The above sketch shows a predicted average cost at $186.32. For every increase in case-flow, the average cost per case would decrease by $1.32.

U-Shaped Form

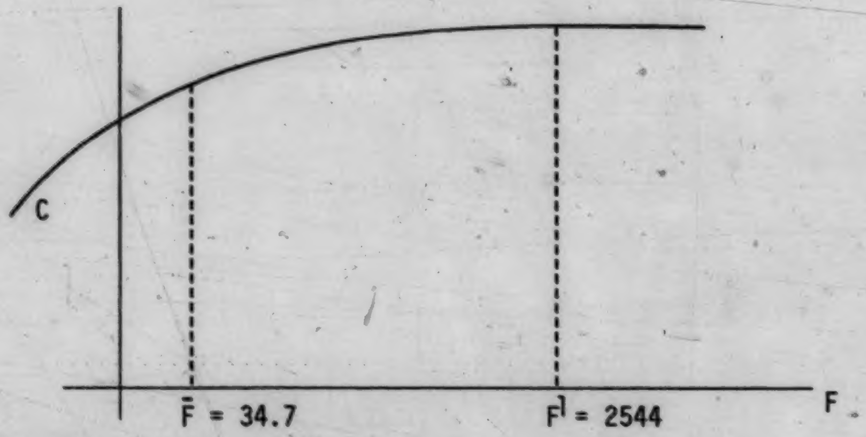
(I-14)

$$\hat{C} = \underset{(105.7)}{146.9} + \underset{(5.51)}{3.46}F - \underset{(7.6\text{x}10^{-4})}{6.7\text{x}10^{-4}}F^2$$

$$t = 1.39 \quad t = 0.627 \quad t = -0.894$$

$$R^2 = 0.20$$

The above regression equation shows that none of the terms has statistical significance at either the one percent level or the five percent level of significance. The R^2 value is noted to be low.



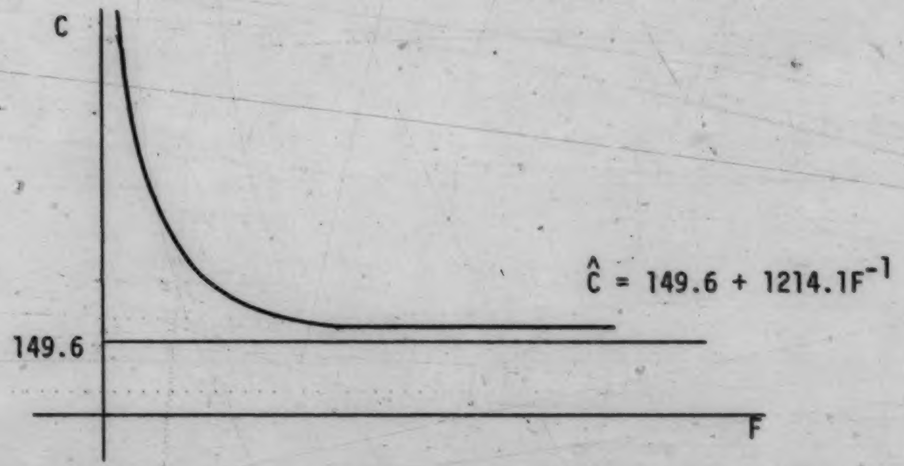
The above sketch depicts an inverted U-shaped average cost curve, which appears to be rising through the relevant range. The optimal case-flow rate at $F^1 = 2544$ is an artifact, and it is not an economically meaningful figure. The curve denotes that as case-flow increases, nursing service costs increase up to this maximum case-flow rate.

Inverse Form

(I-15)
$$\hat{C} = 149.6 + 1214.1F^{-1}$$
$$(45.7) \quad (1529.8)$$
$$t = 3.27^{*} \quad t = 0.794$$
$$R^2 = 0.07$$

*Significant at $\alpha = 0.05$; $\alpha = 0.01$

The estimated relationship between the average nursing service cost and case-flow as determined by the inverse form of the regression equation shows that the intercept term is significant at the five percent and the one percent level of significance. The case-flow coefficient, however, is statistically insignificant.



It is noted that for the above curve, the intercept term in the regression equation is significant. Mathematically, this is represented by a cost curve approaching an L shape, or asymptotic level as illustrated above. The interpretation is that nursing service costs are not fixed throughout the entire range.

Comparing the three preceding regression equations it can be seen that the U-shaped form provides the best fit, although there is little evidence to substantiate the theory that nursing service costs for hospitals in the 100-299 size class are U-shaped on the basis of empirical results depicting a rising cost curve in the relevant range.

Overall Results

An examination of table 8 reveals that the inverse form of the equation provides a better fit in terms of R^2 values in three out of four cases. This finding does not hold true for the 100-299 size class.

TABLE 8

ESTIMATED RELATIONSHIPS BETWEEN AVERAGE NURSING SERVICE COSTS AND CASE-FLOW BY HOSPITAL SIZE, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Specification	$\hat{C}=\hat{\alpha}_0+\hat{\alpha}_1F$	$\hat{C}=\hat{\alpha}_0+\hat{\alpha}_1F+\hat{\alpha}_1F^2$	$\hat{C}=\hat{\alpha}_0+\hat{\alpha}_1F^{-1}$
1-24 Beds	$\hat{C}=278.0 \quad - 3.88F$ $(29.0) \quad (.914)$ $t=9.57^* \quad -4.24^*$ $R^2=0.47$	$\hat{C}=280.5 \quad - 4.10F \quad + 4.0\times10^{-5}F^2$ $(34.6) \quad (1.80) \quad (3.1\times10^{-4})$ $t=8.12^* \quad -2.28^* \quad 0.144$ $R^2=0.47$	$\hat{C}=60.1 \quad + 2622.1F^{-1}$ $(15.1) \quad (355.5)$ $t=3.99^* \quad 7.38^*$ $R^2=0.73$
25-49 Beds	$\hat{C}=198.9 \quad - 2.04F$ $(11.6) \quad (.302)$ $t=17.1^* \quad -6.75^*$ $R^2=0.50$	$\hat{C}=248.0 \quad - 4.89F \quad + 3.8\times10^{-4}F^2$ $(21.3) \quad (1.10) \quad (1.4\times10^{-4})$ $t=11.65^* \quad -4.40^* \quad 2.68^*$ $R^2=0.57$	$\hat{C}=68.1 \quad + 1820.7F^{-1}$ $(5.15) \quad (151.6)$ $t=13.22^* \quad 12.01^*$ $R^2=0.76$
50-99 Beds	$\hat{C}=246.4 \quad - 3.02F$ $(18.1) \quad (.530)$ $t=13.6^* \quad -5.70^*$ $R^2=0.55$	$\hat{C}=284.0 \quad - 5.34F \quad + 3.4\times10^{-4}F^2$ $(71.1) \quad (4.26) \quad (6.2\times10^{-4})$ $t=3.99^* \quad -1.25 \quad 0.548$ $R^2=0.55$	$\hat{C}=42.5 \quad + 3269.6F^{-1}$ $(17.5) \quad (541.2)$ $t=2.42^* \quad 6.04^*$ $R^2=0.57$
100-299 Beds	$\hat{C}=231.3 \quad - 1.32F$ $(46.9) \quad (1.33)$ $t=4.94^* \quad -0.992$ $R^2=0.11$	$\hat{C}=146.9 \quad + 3.46F \quad - 6.8\times10^{-4}F^2$ $(105.7) \quad (5.51) \quad (7.6\times10^{-4})$ $t=1.39 \quad 0.627 \quad -0.894$ $R^2=0.20$	$\hat{C}=149.6 \quad + 1214.1F^{-1}$ $(45.7) \quad (1529.8)$ $t=3.27^* \quad 0.794$ $R^2=0.07$

*Significant at $\hat{\alpha} = 0.05$

With respect to the inverse form, the intercept term is statistically significant in each of the four size classes. Thus, the cost curve for each of these groups would be an L shaped curve, indicating that as case-flow increases, the average cost curve reaches a constant value. The R^2 values for estimated relationships in the 1-24 size group, and the 25-49 size group are reasonably high and suggest good fits demonstrating that case-flow would appear to explain a high proportion of variance. For the 50-99 size class, the R^2 value is somewhat lower, and for the 100-299 size class the R^2 value is exceptionally low. As hospitals increase in size as determined by rated bed capacity, the tendency for average fixed nursing service costs to have the shape of rectangular hyperbolas becomes less.

The quadratic equations show reasonably good fits in terms of R^2 values; however, there are only marginal improvements in these values over the linear forms of the equations. With the exception of the 100-299 size class, all groups depict the traditional U-shaped cost curve. For the 100-299 size class the cost curve is an inverted U-shape, as illustrated on page 60, this study, and the R^2 value, although low, provides a better fit than either the linear or the inverse form of the equation.

Part 2: The Effect of Interclass Hospital Size Variations on Average Nursing Service Cost Relationships

As discussed previously, in the short-run average cost does not vary with size of plant; however, utilization of plant capacity does vary. The specifications to estimate relationships between average nursing service costs and case-flow, holding plant size constant, are identical to those for average general administration costs (see I-7 to I-9).

Regression Results

When a scale factor was introduced in order to hold hospital size constant (table 9), minimal changes were noted in cost with respect to changes in case-flow for three of the size classes. The most notable changes occurred in the 100-299 size class, as might be anticipated due to the wider variation in plant size within this class. The R^2 value for the linear equation increased from $R^2 = 0.11$ to $R^2 = 0.60$, while the R^2 values for the quadratic and inverse form of the equation went from $R^2 = 0.20$ to $R^2 = 0.73$, and $R^2 = 0.07$ to $R^2 = 0.63$ respectively.

In effect, allowance must be made for differences in hospital size in calculating the short-run average nursing service costs. Inter-hospital variation in the number of beds and the variation in capacity utilization, are critical, particularly for hospitals in the 100-299 bed range.

The interesting finding with respect to nursing service costs for estimated relationships both with and without the inclusion of a scale factor is that, contrary to theoretical expectations, for all groups, with the exception of the 50-99 and the 100-299 size classifications, the inverse form of the equation provides as good a fit or better than the quadratic equations. This finding suggests that the average cost curves for all groups with less than fifty beds are seemingly L-shaped, and average costs are decreasing as the level of output increases, due to the fact that the total fixed costs are spread

TABLE 9

RELATIONSHIPS BETWEEN AVERAGE NURSING SERVICE COSTS AND CASE-FLOW AND HOSPITAL SIZE, ALBERTA GENERAL HOSPITALS, 1971

Specification	$\hat{C}=\alpha_0+\alpha_1F+\alpha_2B$	$\hat{C}=\alpha_0+\alpha_1F+\alpha_2F^2+\alpha_3B+\alpha_4B^2$	$\hat{C}=\alpha_0+\alpha_1F^{-1}+\alpha_2B$
1-24 Beds	$\hat{C}=329.4 - 4.21F - 2.49B$ (47.7) (.930) (1.85) t=6.91* -4.53* -1.35 $R^2=0.52$	$\hat{C}=510.2 - 6.38F + 3.2\times10^{-4}F^2 - 22.2B + 6.07\times10^{-3}B^2$ (126.7) (2.03) (3.2×10^{-4}) (13.6) (4.22×10^{-3}) t=4.03* -3.14* 0.998 -1.63 1.44 $R^2=0.58$	$\hat{C}=93.5 + 2752.9F^{-1} - 2.32B$ (23.0) (343.1) (1.25) t=4.06* 8.02* -1.85 $R^2=0.77$
25-49 Beds	$\hat{C}=205.5 - 2.02F - .217B$ (21.0) (.306) (.571) t=9.79* -6.62* -0.380 $R^2=0.51$	$\hat{C}=249.1 - 4.91F + 3.8\times10^{-4}F^2 + .265B - 9.0\times10^{-5}B^2$ (102) (1.16) (1.5×10^{-4}) (5.48) (7.8×10^{-4}) t=2.44* -4.22* 2.58* 0.048 -0.116 $R^2=0.58$	$\hat{C}=79.7 + 1813.7F^{-1} - .351B$ (13.9) (152.1) (.390) t=5.73* 11.9* -0.893 $R^2=0.77$
50-99 Beds	$\hat{C}=207.9 - 2.91F + .572B$ (32.4) (.526) (.403) t=6.42* -5.53* 1.42 $R^2=0.58$	$\hat{C}=-106.9 - 5.80F + 4.4\times10^{-4}F^2 + 12.2B - 9.2\times10^{-4}B^2$ (216.3) (4.10) (5.9×10^{-4}) (6.39) (5.1×10^{-4}) t=0.494 -1.41 0.746 1.91 -1.81 $R^2=0.64$	$\hat{C}=6.07 + 3170.8F^{-1} + .650B$ (27.3) (526.4) (.382) t=.222 6.02* 1.70 $R^2=0.62$
100-299 Beds	$\hat{C}=182.7 - 1.32F + .295B$ (37.7) (.960) (.102) t=4.85* -1.38 2.90* $R^2=0.60$	$\hat{C}=192.1 - 5.06\times10^{-2}F - 1.9\times10^{-4}F^2 + .162B - 1.0\times10^{-5}B^2$ (83.1) (5.75) (8.0×10^{-4}) (.180) (1.0×10^{-5}) t=2.31 .009 -0.242 0.899 -1.45 $R^2=0.73$	$\hat{C}=81.5 + 1734.5F^{-1} + .320B$ (37.2) (1043.5) (.098) t=2.19 1.66 3.26 $R^2=0.63$

*Significant at $\alpha = 0.05$

over more units of output. It may be that rural hospitals (those hospitals with less than fifty beds) are more "stable" in terms of input resources than those hospitals with 100 beds and over. Reference to the functions of nursing services (page 8 this study) and the resulting costs incurred, particularly with regard to supplies and other expenses including medical and surgical supplies and drugs, may provide some insight into why these costs tend to reach a certain minimum level in the smaller hospitals. The diagnostic-mix of patients in hospitals with less than fifty beds would most probably not be as varied or as complex as in larger hospitals. For example, smaller hospitals are often not equipped to handle complex cases, and therefore these patients should be referred to larger centres. Examples of areas in which nursing service expenses might be considerably lower in smaller hospitals are operating rooms and emergency units. By treating more "routine" cases, smaller hospitals would tend to use fewer variable input resources, and thus nursing service costs would not be as variable. Patients are often examined and treated in emergency and out-patient departments when there is insufficient medical need. It appears that physicians are seeing fewer patients in their offices, particularly in the large centres. The result is that hospital costs increase, and suggests an uneconomical and inefficient use of resources.

Hospitals ranging in capacity from 100-299 beds depict a U-shaped average cost curve, although when a measure of hospital size was included in the regression equation, there was only a marginal improvement in the R^2 value for the quadratic equation over the R^2 value for the inverse form of the equation.

Section IV: Interhospital Differences in Rates of Responsiveness in Average Cost and Case-Flow

In order to determine whether or not significant differences exist between hospital size classes in rates of responsiveness in average costs and case-flow, an analysis of covariance using a linear regression model was carried out. The 25-49 bed size class was chosen as the base group. The basic specification is as follows:

Basic Specification:

$$\hat{C} = \alpha_0 + \alpha_1 d_1 + \alpha_2 d_2 + \alpha_3 d_3 + \alpha_4 F + \alpha_5(d_1 F) + \alpha_6(d_2 F) + \alpha_7(d_3 F) + \epsilon_i$$

where d_1 = 1 - 24 size class
d_2 = 50 - 99 size class
d_3 = 100 - 299 size class
F = case-flow
and ϵ_i = stochastic, or error term

Analysis of Covariance Results

Average General Administration Costs

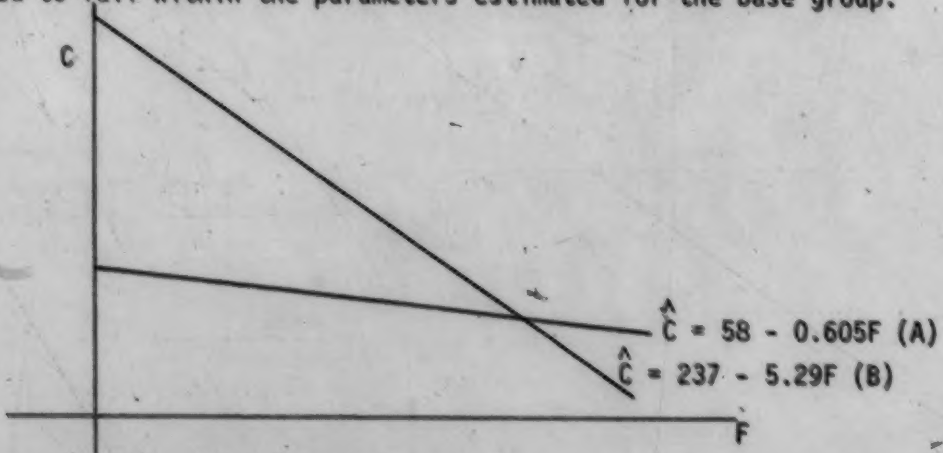
Applying the general specification to average general administration costs, the following equation depicts the empirical results:

$$\begin{array}{llllllll}
\hat{C} = 58.0 & + 43.2d_1 & + 179d_2 & + 4.62d_3 & - .605F & - 1.40d_1F & - 4.69d_2F & \\
(54.4) & (66.5) & (70.3) & (115.9) & (1.37) & (1.92) & (1.91) & \\
t = 1.07 & T=0.650 & t=2.55^{*} & t=0.399 & t=0.441 & t=-0.731 & t=-2.45^{*} & \\
 & & & & & +.168d_3F & & \\
 & & & & & (3.21) & & \\
 & & & & & t=0.052 & &
\end{array}$$

R^2=0.30

*Significant at α = 0.05

In reference to the above equation, both the differential intercept and slope terms for the 50-99 hospital size group are statistically significant at the five percent level. On the basis of these findings, clearly, the 50-99 size class is significantly different from the 25-49 size class in terms of average general administration costs and case-flow, while the remaining classes can be considered to fall within the parameters estimated for the base group.



Code: (A) 25-49 size class
(B) 50-99 size class

The above sketch illustrates that both the differential intercept term and the slope term for the 50-99 size class vary from the corresponding terms for the 25-49 size class. For the 50-99 size class, as case-flow increases, there is a very rapid decrease in average general administration costs. These costs for the latter group are higher than those for the remaining groups, suggesting a heavier administration outlay.

Average Nursing Administration Costs

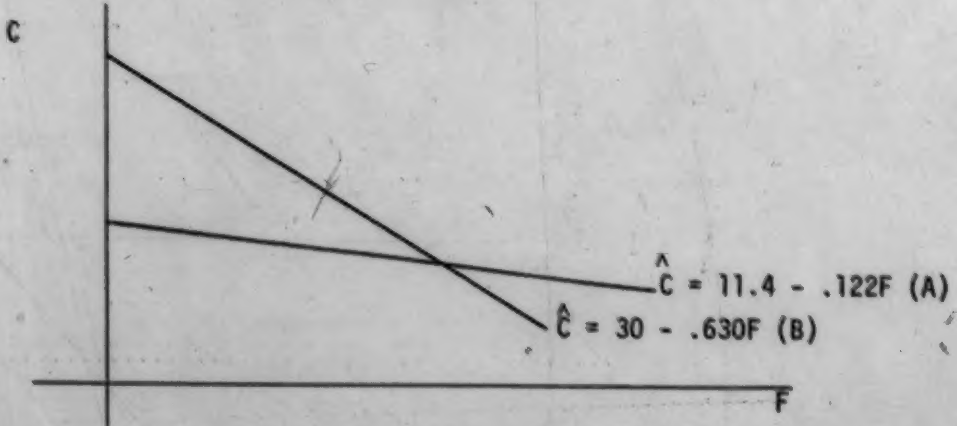
The basic specification was applied to average nursing administration costs. The following equation presents the estimated results.

$$\begin{array}{lllllll}
\hat{C} = 11.4 + 9.63d_1 & + 18.6d_2 & + 9.22d_3 & - .122F & - .134d_1F & - .508d_2F \\
\quad (6.78) \; (8.28) & (8.75) & (14.4) & (.170) & (.239) & (.238) \\
t = 1.68 \quad t=1.16 & t=2.13^{*} & t=0.640 & t=0.714 & t=0.558 & t=-2.14^{*}
\end{array}$$

$$\begin{array}{l}
- .118d_3F \\
(.399) \\
t = -0.295 \\
R^2 = 0.38
\end{array}$$

*Significant at $\alpha = 0.05$

As previously determined for average general administration costs, the above equation indicates that both the differential intercept and slope terms for the 50-99 size class are statistically significant from the corresponding terms in the base group, the 25-49 size class. The remaining size classes can be considered to fall within the parameters of the base group.



Code: (A) 25-49 size class
(B) 50-99 size class

In reference to the above sketch it can be seen that higher average nursing administration costs are depicted for hospitals in the 50-99 size class than for those in the 25-49 size class, and they decline more rapidly as case-flow increases. This observation may indicate a higher nursing administrative staff-ratio in the 50-99 size class.

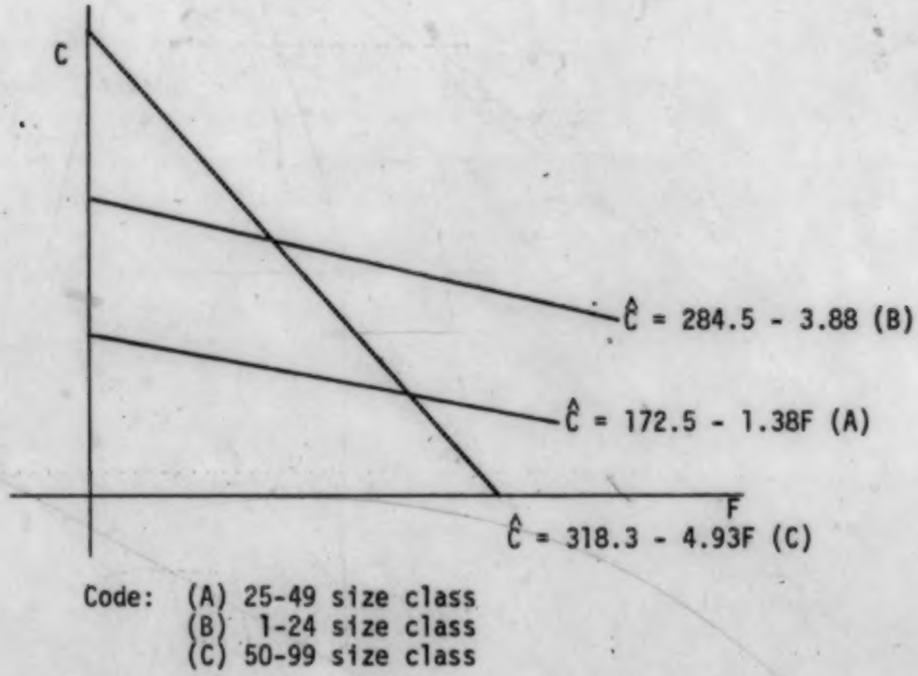
Average Nursing Service Costs

The basic specification was applied to average nursing service costs. The following equation presents the estimated results:

$$
\begin{array}{lllllll}
\hat{C} = 172.5 & + 112.0d_1 & + 145.8d_2 & + 21.1d_3 & - 1.38F & - 2.50d_1F & - 3.55d_2F \\
(44.0) & (53.8) & (56.8) & (93.7) & (1.11) & (1.55) & (1.55) \\
t = 3.92^* & t=2.08^* & t=2.57^* & t=0.225 & t=-1.25 & t=-1.61 & t=-2.29^* \\
 & & & & & + .974d_3F & \\
 & & & & & (2.59) & \\
 & & & & & t=0.376 & \\
 & & & & & R^2 = 0.55 &
\end{array}
$$

*Significant at $\alpha = 0.05$

The above equation depicts four significant terms at the five percent level of significance: the base intercept term; the differential intercept term for the 1-24 size class; the differential intercept term for the 50-99 size class; and the differential slope term for the 50-99 size class.



The preceding sketch illustrates the relationships among the differential intercept terms and the differential slope terms for the three hospital size classes under 100 beds. The three intercept terms are significantly different. The interpretation is that nursing service costs, or outlay is lowest for the 25-49 size class; somewhat higher for the 1-24 size class; and highest for the 50-99 size class. There is no significant difference in the rate of decrease of average costs with increases in case-flow between the 1-24 and 25-49 size classes; however, there is a significant difference between the decline in average nursing service costs over an increased range in output between the 50-99 size class and the 25-49 size class. Average nursing service costs decline significantly faster for the 50-99 size class. This finding is suggestive of a relatively high level of total nursing service costs, which fall relatively rapidly.

Total nursing service costs are increasing at a decreasing rate.

In sum, there was a significant difference between the 50-99 size class and the 25-49 size class for general administration costs, nursing administration costs and nursing service costs, when analysis of covariance was done using a linear form of the equation, indicating higher initial costs in all three cases for the 50-99 group, which decline more rapidly than the base group as output increases.

Economic Observations: A Summary Overview

Relationships between average costs and case-flow rates were estimated by applying ordinary least squares regression analysis using three types of functions: linear; quadratic; and the inverse form of the equation in the short-run for a sample of general public hospitals in Alberta, subdivided into size classes. Average costs considered were general administration, nursing administration, and nursing service.

On the basis of theory, it was argued that total general administration costs and total nursing administration costs would tend to behave as fixed costs, and that total nursing service costs would tend to behave as variable costs. Empirical findings of this study support the theoretical expectations with respect to both administration costs; however, nursing service costs were found to be L-shaped, with the exception of the 100-299 size class.

It was assumed that hospital size within classes would not have an effect on costs in the short-run. Due to the variation in plant capacity within the size classes, however, it was relevant to determine if hospital size did have an effect on average costs. Estimated relationships, including a measure of hospital size (holding the number of beds constant), resulted in only marginal improvements which did not change the shape of the cost curves for general administration and nursing administration. With respect to nursing service costs, minimal changes were found for three of the four size classes, while substantial improvement was noted for the linear, quadratic and inverse form of the equation in the 100-299 size class. Variation in plant capacity within this size class had an effect on costs, and indeed contributed explanatory power.

In order to determine whether there were significant differences in estimates obtained among the size classes, an analysis of covariance was carried out using a linear model, with the 25-49 size class as the base group. Significant differences were found between the 50-99 size class and the 25-49 size class for all three costs.

CHAPTER IV

ECONOMETRIC ANALYSIS OF SHORT-RUN AVERAGE COSTS ACCOUNTING FOR CASE-MIX VARIATION

Introduction

The analysis carried out in the preceding chapter was predicated upon the assumption that inter-hospital variation in case-mix would not significantly affect the estimations of the cost functions in each size of hospital class. This may be an "heroic" assumption.

Feldstein contends that

> . . .the extent to which acute hospitals differ in the mix of cases treated is commonly underestimated. The current system of hospital costing and the usual procedure of comparing hospital costs with national averages indicate an assumption that case-mix differences are either not substantial or have little influence on costs.[1]

In the above study, nine mutually exclusive categories were derived essentially from various hospital specialties, and the proportion of cases in each category was calculated for 177 hospitals for 1960. Feldstein concluded that there was a high degree of inter-hospital variation when case-mixes of large acute hospitals were represented by nine broad specialty categories. The resulting case-mix differences analyzed on the basis of linear relationships were used to determine the proportion of total variance in a particular cost attributable to case-mix differences. Empirical results showed that 27.5 percent of the variation in ward costs per case was due to case-mix.[2] Feldstein concludes that any attempts to compare hospital costs and other characteristics (for example, the number of beds) should, therefore, take case-mix into account.[1]

---

[1] Feldstein, Economic Analysis for Health Service Efficiency, p. 15.

[2] Ibid., p. 23.

The purpose of this chapter is to estimate the effect of variations in case-flow upon average general administration costs, average nursing service costs, and average nursing administration costs once an accounting has been made for inter-hospital variations in case-mix.

The format is as follows: the chapter is divided into three sections. Each of the three sections contains, or refers to, the general specification of each cost function, illustrations of the three specific forms of the regression equations (linear, quadratic, and the inverse form), and a presentation and discussion of the results. Each section contains two parts. Part one sets out the estimated relationships for each of the three average costs and case-flow, including a measure of hospital capacity defined as the number of beds. Part two presents the expected optimal case-flow rates for each of the case-mix classifications. Finally, a summary overview of the economic observations is provided.

Data

The data for this section are based on the total study sample of 115 general public hospitals in Alberta, and six relatively homogeneous subgroups of this total, classified according to case-mix composition. In order to cluster hospitals into case-mix groups, data were derived from monthly discharge lists for 1971, compiled by the Commission on Professional and Hospital Activities, Ann Arbor, Michigan, obtained from the Alberta Hospital Services Commission. A summary file of discharges from all hospitals included in this study and the corresponding ICDA codes was created. The data were subjected to statistical techniques including Q-type correlation and factor analysis to classify them in terms of case-mix.[1] Hospitals in case-mix Groups I to V inclusive correlated at 0.8 or greater in case-mix, whereas Group VI hospitals did not have high enough correlations to be classified with any of the five groups. This latter group is, therefore, not representative of a particular case-mix. Groups II and V are the most similar, and Groups III and IV are the least similar.[2] "This grouping provides neither mutually exclusive nor exhaustive classification of hospitals."[3] Appendix B presents the hospitals as grouped on the basis of case-mix.

---

[1] Ibid., p. 24.

Descriptive statistics for the total sample and case-mix groups are reported in table 10. Even within a range of hospitals from seven to 1,068 beds, there is not a wide variation in case-flow rates, the range being from 8.8 to 65.2 with a mean of 34.1. This is a greater range than in Feldstein's findings in which he found the variation ranged from 9.41 to 40.48 cases per bed year, with a mean of 23.18.[4] In the study presented here, Group II has the greatest mean number of beds (144.7), and Group III the lowest (33.1). It is interesting to

---

[1] Bay, Flathman, and Plain, p. 1.

[2] Ibid., p. 5. [3] Ibid., p. 4.

[4] Feldstein, Economic Analysis for Health Service Efficiency, p. 128.

TABLE 10

DESCRIPTIVE STATISTICS FOR TOTAL SAMPLE AND HOSPITALS CLASSIFIED
BY CASE-MIX, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

			HOSPITAL GROUPS					
VARIABLE		TOTAL SAMPLE	I	II	III	IV	V	VI
		N=115	N=33	N=54	N=16	N=31	N=39	N=18
Number of Hospital Beds	Mean	92.6	36.9	144.7	33.1	102.3	67.2	80.4
	Med.	34.8	32.3	53.8	32	51.8	51	24.5
	S.D.	185	23.1	240.1	16.7	129.4	84.3	176.8
	Rge.	1061	128	1053	61	530	533	758
	Min.	7.0	7	15	9	25	22	8
	Max.	1069	135	1068	70	555	555	766
Case-Flow	Mean	34.1	36.1	34.6	31.3	38.8	36.9	28.9
	Med.	33.3	35.7	33.5	31.0	37.3	35.1	29.3
	S.D.	9.69	8.9	8.2	7.1	9.7	10	11.7
	Rge.	56.4	46.8	36.5	23.2	42.5	47.2	39.6
	Min.	8.8	18.4	18.0	18.4	22.7	18.0	8.8
	Max.	65.2	65.2	54.5	41.6	65.2	65.2	48.4
Average General Administration Cost	Mean	46.0	37	49	49	42	41	54
	Med.	39.0	31	42	40	35	39	45
	S.D.	25.0	21	24	27	22	21	29
	Rge.	116	112	103	106	96	97	115
	Min.	15	15	20	20	22	20	16
	Max.	131	127	124	127	118	118	131
Average Nursing Administration Cost	Mean	9.0	7	8	7	7	7	15
	Med.	7.0	7	7	6	6	6	13
	S.D.	5.0	3	3	3	4	4	9
	Rge.	30	13	12	12	17	17	29
	Min.	2	2	3	3	2	2	3
	Max.	32	15	15	15	19	19	32
Average Nursing Service Cost	Mean	150	124	159	138	143	136	181
	Med.	136	122	149	134	129	127	162
	S.D.	51	24	51	30	43	35	71
	Rge.	272	96	269	91	166	166	235
	Min.	79	87	82	100	79	79	99
	Max.	351	183	351	191	244	244	334

Note: Med. = Median
S.D. = Standard Deviation
Rge. = Range

note that Group VI has a mean of 80.4 beds and a mean case-flow rate of 28.9, the lowest rate for any group. At the same time, this group has the highest average costs per general administration ($54.00); nursing administration ($15.00); and for nursing service ($181.00). Group I with a case-flow rate of 36.1 (second highest) consistently has the lowest average costs.

Section I: The Analysis of Average General Administration Cost Relationships

Part 1: Average General Administration Costs and Case-Flow

One would expect total administration costs to be fixed costs, and consequently average costs would decrease as volume of output increases. Short-run average cost curves were determined for the total study sample and case-mix groups using the case-flow rate as the measure of intensity of capacity utilization. The estimations are based on a "given" capacity, by including a measure of hospital size in the equation. Thus the relationships show how average costs respond to change in output expressed as case-flow in cross-section analyses.

The specifications will be referred to as linear, quadratic, and the inverse form, with the understanding that reference is being made to the postulated relationships between average costs and case-flow. The basic specifications are as follows:

Linear (II-1) $C = \alpha_0 + \alpha_1 F + \alpha_2 B + \epsilon_i$

where C represents average general administration cost per case; F represents case-flow, B represents hospital size in terms of number of beds; and ϵ_i represents the stochastic or error term.[1]

Quadratic (II-2) $C = \alpha_0 + \alpha_1 F + \alpha_2 F^2 + \alpha_3 B^2 + \epsilon_i$

Inverse Form (II-3) $C = \alpha_0 + \alpha_1 F^{-1} + \alpha_2 B + \epsilon_i$

Regression Results

The following regression equations illustrate the relationships between cost and case-flow, holding the number of hospital beds constant for group I hospitals.

Linear Form

(II-4)
$$\hat{C} = 76.1 - 1.23F + .130B$$
$$(14.1) \quad (.351) \quad (.136)$$
$$t = 5.40^{*} \quad t = -3.50^{*} \quad t = 0.96$$
$$R^2 = 0.31$$

*Significant at $\alpha = 0.50$; $\alpha = 0.01$

In the above equation, the intercept term and the regression coefficient of F are significant at the five percent and one percent levels of significance. Cost per case is observed to decrease with an increase in case-flow, while cost per case increases with an increase in the number of beds. The mean number of admission per bed year is 36.1 with a mean general administration cost of $37.00. On the basis of these findings, the projected mean cost is $38.23.

U-shaped Form

(II-5)

$$\hat{C} = 166 - 6.19F + 0.63F^2 + .226B - 7.0\text{x}10^{-4}B^2$$

$$(33.9) \quad (1.59) \quad (0.02) \quad (1.36) \quad (2.66\text{x}10^{-3})$$

$$t = 4.90^{*} \quad t = 3.88^{*} \quad t = 3.18^{*} \quad t = 0.62 \quad t = -0.26$$

$$R^2 = 0.50$$

*Significant at $\alpha = 0.05$; $\alpha = 0.01$

In the preceding equation there are three statistically significant terms at the five percent and one percent levels: the intercept term; the regression coefficient of F; and the F squared term. Cost per case decreases, reaches a minimum (at F = 49.1), and then begins to increase. As the actual mean case-flow rate is 36.1, it is observed that hospitals in this group are operating somewhat below their optimal case-flow rate which would result in lower average general administration costs.

Inverse Form

(II-6)

$$\hat{C} = -23.8 + 1890.5F^{-1} + .129B$$

$$(11.0) \quad (338.9) \quad (.113)$$

$$t = 2.16^{*} \quad t = 5.58^{**} \quad t = 1.14$$

$$R^2 = 0.52$$

*Significant at $\alpha = 0.05$

**Significant at $\alpha = 0.05$; $\alpha = 0.01$

With reference to the above equation the intercept term is statistically significant at the five percent level, and the regression coefficient of F is significant at both the five percent and one percent levels of significance.

Clearly, on the basis of the preceding three regression equations, there is little justification for choosing either the inverse form of the equation or the quadratic equation in terms of predictive power. The R^2 values are approximately the same, although marginally higher for the inverse form.

Overall Results

Table 11 gives an overview of estimated relationships for the total sample and case-mix groups. Overall, the inverse or quadratic functions appear to have somewhat better fits (higher R^2 values) than the linear relationships. There appears to be little basis for choosing between the quadratic or inverse relationships, with the exception of group III where the U-shaped form seemingly provides the best fit. For the total sample and all groups, the reasonably good fits for the quadratic equations suggest that case-flow would approach an optimal rate which would minimize the costs per case.

Group III hospitals range in capacity from nine to seventy beds (table 10). For this group of hospitals, average general administration costs initially decrease as the level of output increases, up to a certain point. Beyond that level of output, average costs begin to rise. Thus the case-mix for this group of hospitals is such that general administration input resources would appear to reach some upper limit, at which point the cost of treating additional patients exceeds the fixed and variable costs associated with production, i.e., general administration.

It is useful to demonstrate the optimal level of case-flow

TABLE 11

ESTIMATED RELATIONSHIPS BETWEEN AVERAGE GENERAL ADMINISTRATION COSTS AND CASE-FLOW AND HOSPITAL SIZE, TOTAL SAMPLE AND CASE-MIX GROUPS, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Specification	$\hat{C} = \alpha_0 + \alpha_1 F + \alpha_2 B$	$\hat{C} = \alpha_0 + \alpha_1 F + \alpha_2 F^2 + \alpha_3 B + \alpha_4 B^2$	$\hat{C} = \alpha_0 + \alpha_1 F^{-1} + \alpha_2 B$
Total Sample	$\hat{C} = 91.4 - 1.46F + 4.99 \times 10^{-2} B$ $(6.13)\ (.169)\ (8.84 \times 10^{-3})$ $t = 14.91^* \ -8.67^* \ 5.64^*$ $R^2 = 0.52$	$\hat{C} = 138.9 - 4.63 + 4.48 \times 10^{-2} F^2 + .140B - 1.0 \times 10^{-4} B^2$ $(12.3)\ (.702)\ (9.7 \times 10^{-3})\ (3.02 \times 10^{-2})\ (3.0 \times 10^{-5})$ $t = 11.30^* \ -6.60^* \ 4.62^* \ 4.65 \ -3.01$ $R^2 = 0.61$	$\hat{C} = 7.03 + 1039.9F^{-1} + .0570B$ $(4.31)\ (121.1)\ (8.81 \times 10^{-3})$ $t = 1.63 \ 8.59^* \ 6.47^*$ $R^2 = 0.51$
Group I	$\hat{C} = 76.1 - 1.23F + .130B$ $(14.1)\ (.351)\ (.136)$ $t = 5.40^* \ -3.50^* \ 0.96^*$ $R^2 = 0.31$	$\hat{C} = 166 - 6.19F + 0.63F^2 + .226B - 7.0 \times 10^{-4} B^2$ $(33.9)\ (1.59)\ (.020)\ (.364)\ (2.66 \times 10^{-3})$ $t = 4.90^* \ -3.88^* \ 3.18^* \ 0.62 \ -0.26$ $R^2 = 0.50$	$\hat{C} = -23.8 + 1890.5F^{-1} + .129B$ $(11.0)\ (338.9)\ (.113)$ $t = 2.16^* \ 5.58^* \ 1.14$ $R^2 = 0.52$
Group II	$\hat{C} = 108.8 + 1.85F + .032B$ $(9.56)\ (.259)\ (8.82 \times 10^{-3})$ $t = 11.4^* \ -7.13^* \ 3.60^*$ $R^2 = 0.61$	$\hat{C} = 197.4 - 7.42F + .080F^2 + .079B - 5.0 \times 10^{-5} B^2$ $(30.8)\ (1.84)\ (.026)\ (.034)\ (3.0 \times 10^{-5})$ $t = 6.42^* \ -4.04^* \ 3.06^* \ 2.35^* \ -1.38$ $R^2 = 0.67$	$\hat{C} = 17.8 + 2029.4F^{-1} + 3.45 \times 10^{-2} B$ $(7.60)\ (243.4)\ (8.02 \times 10^{-3})$ $t = -2.35^* \ 8.34^* \ 4.30^*$ $R^2 = 0.67$
Group III	$\hat{C} = 112.9 - 2.55F + .465B$ $(25.0)\ (.798)\ (.342)$ $t = 4.52^* \ -3.20^* \ 1.36$ $R^2 = 0.45$	$\hat{C} = 367.2 - 20.9F + .294F^2 + 1.79B - 1.97 \times 10^{-2} B^2$ $(69.2)\ (4.42)\ (7.33 \times 10^{-2})\ (1.04)\ (1.3 \times 10^{-2})$ $t = 5.31^* \ -4.72^* \ 4.01^* \ 1.73 \ -1.51$ $R^2 = 0.82$	$\hat{C} = -48.7 + 2.44F^{-1} + .444B$ $(21.8)\ (516.8)\ (.273)$ $t = 2.23^* \ 4.72^* \ 1.62$ $R^2 = 0.64$

*Significant at $\alpha = 0.05$

TABLE 11 (Continued)

Specification	$\hat{C} = \alpha_0 + \alpha_1 F + \alpha_2 B$	$\hat{C} = \alpha_0 + \alpha_1 F + \alpha_2 F^2 + \alpha_3 B + \alpha_4 B^2$	$\hat{C} = \alpha_0 + \alpha_1 F^{-1} + \alpha_2 B$
Group IV	$\hat{C} = 73.2 - 1.00F + 8.0\times10^{-2}B$ $(12.6) \quad (.294) \quad (2.20\times10^{-2})$ $t=5.81^* \quad -3.42^* \quad 3.63^*$ $R^2=0.57$	$\hat{C} = 154.6 - 5.19F + 5.05\times10^{-2}F^2 + 8.75\times10^{-2}B - 1.6\times10^{-5}B^2$ $(34.6) \quad (1.69) \quad (2.01\times10^{-2}) \quad (7.89\times10^{-2}) \quad (1.4\times10^{-4})$ $t=4.47^* \quad -3.08^* \quad 2.51^* \quad 1.11 \quad -0.08$ $R^2=0.67$	$\hat{C} = -11.4 + 1664.5F^{-1} + 8.07\times10^{-2}B$ $(10.0) \quad (369.3) \quad (19.6\times10^{-2})$ $t=-1.14 \quad 4.51 \quad 4.12$ $R^2=0.65$
Group V	$\hat{C} = 70.9 - 1.0F + .115B$ $(10.0) \quad (.248) \quad (2.95\times10^{-2})$ $t=7.09^* \quad -4.08^* \quad 3.89^*$ $R^2=0.52$	$\hat{C} = 151.1 - 5.50F + 5.48\times10^{-2}F^2 + .225B - 1.9\times10^{-4}B^2$ $(24.4) \quad (1.20) \quad (1.43\times10^{-2}) \quad (.112) \quad (1.9\times10^{-4})$ $t=6.19^* \quad -4.59^* \quad 3.84^* \quad 2.01 \quad -0.98$ $R^2=0.67$	$\hat{C} = -13.7 + 1627.7F^{-1} + .117B$ $(7.95) \quad (266.6) \quad (2.48\times10^{-2})$ $t=-1.72 \quad 6.11 \quad 4.72$ $R^2=0.66$
Group VI	$\hat{C} = 92.6 - 1.64F + .110B$ $(7.69) \quad (.244) \quad (1.62\times10^{-2})$ $t=12.05^* \quad -6.73^* \quad 6.75^*$ $R^2=0.86$	$\hat{C} = 107.1 - 3.05F + 2.32\times10^{-2}F + .223B - 1.4\times10^{-4}B^2$ $(15.0) \quad (1.15) \quad (2.03\times10^{-2}) \quad (8.61\times10^{-2}) \quad (1.1\times10^{-4})$ $t=7.15^* \quad -2.66^* \quad 1.14 \quad 2.60^* \quad -1.30$ $R^2=0.89$	$\hat{C} = 13.0 + 717.2F^{-1} + 119B$ $(6.15) \quad (115.9) \quad (1.73\times10^{-2})$ $t=2.11 \quad 6.19 \quad 6.87$ $R^2=0.84$

*Significant at $\alpha = 0.05$

which would result in lowest average general administration costs.

Part 2: Expected Optimal Case-Flow

By calculating partial derivatives, which in this case determine the change in the average cost per case for a small change in one variable, case-flow, holding hospital size constant, optimal case-flow rates were estimated.

Table 12 shows the implied turning points for average general administration costs.

TABLE 12[1]

EXPECTED OPTIMAL CASE-FLOW RATES FOR AVERAGE GENERAL ADMINISTRATION COST FUNCTIONS, TOTAL SAMPLE AND CASE-MIX GROUPS, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Hospital Groups	Total Sample	I	II	III	IV	V	VI
Expected Optimal Case-Flow	51.7	49.1	47.0	35.5	51.4	50.1	65.7

[1] Calculated from table 11

A comparison of mean case-flow rates (table 10) and estimated optimal case-flow indicates that taken together all hospitals are operating at 66.0 percent of their optimal case-flow: group I at 73.5 percent; group II at 73.5 percent; group III at 88.2 percent; group IV at 75.5 percent; group V at 73.7 percent and group VI at 44.0 percent. It is interesting to note that in comparison to the other groups, group III is operating at the highest percentage of optimal case-flow, which lends support to the finding that the estimated cost curve for this group tends to be U-shaped. The results suggest that the remaining groups are operating below their optimal level of activity, which demonstrates a "wastage" of expenses for general administration.

Section II: The Analysis of Average Nursing Administration Cost Relationships

Part 1: Average Nursing Administration and Case-Flow

Following the basic premise that total administration costs would be fixed costs, and average costs would tend to decrease with an increase in volume of output, short-run average cost functions were estimated for nursing administration. Holding hospital size constant, regression equations (the linear, quadratic and inverse functions) were used to predict costs for the total sample and case-mix groups. The basic specifications as set out in II-1 to II-3 are followed.

Regression Results

Estimates of linear, quadratic and inverse average cost functions are presented in equations (II-7), (II-8), and (II-9) for group II. It should be recalled that the average nursing administration cost is \$8.00, and the average case-flow rate is 34.6.

Linear Form

$$\text{(II-7)} \qquad \begin{array}{llll} \hat{C} = & 14.0 & - .192F & + 1.3\text{x}10^{-3}B \\ & (1.97) & (5.4\text{x}10^{-2}) & (1.8\text{x}10^{-3}) \\ & t = 7.11^{*} & t = -3.58^{*} & t = 0.71 \\ & & & R^2 = 0.23 \end{array}$$

*Significant at $\alpha = 0.05$; $\alpha = 0.01$

According to the above equation, cost per case decreases with an increase in case-flow, whereas cost per case increases with an increase in hospital size. The R^2 value of 0.23 is extremely low which indicates that case-flow, although significant at the five percent and the one percent level of significance, in effect explains little in terms of cost variation. The projected average cost is \$8.19.

U-Shaped Form

$$\hat{C} = 19.0 - .475F + 3.99\times10^{-3}F^2 - 2.87\times10^{-3}B + 0.0B^2 \qquad \text{(II-8)}$$

$$\begin{array}{ccccc} (6.86) & (4.10) & (5.8\times10^{-3}) & (7.5\times10^{-3}) & (1.0\times10^{-5}) \\ t = 2.77^* & t = -1.16 & t = 0.687 & t = -0.382 & t = 0.597 \end{array}$$

$$R^2 = 0.25$$

*Significant at $\alpha = 0.05$; $\alpha = 0.01$

The preceding model indicates a slightly U-shaped cost curve with a minimum or turning point of 59.5 cases per bed year. Cost per case decreases throughout the range to this point, then increases. As the actual mean case-flow rate for this group is 34.6, these hospitals are operating somewhat below least cost. The intercept term is significant at the five percent and one percent levels; however, the remaining variables are not significant. The R^2 value is low.

Inverse Form

$$\hat{C} = .931 + 209.3F^{-1} + 1.59\times10^{-3}B \qquad \text{(II-9)}$$

$$\begin{array}{ccc} (1.66) & (53.7) & (1.77\times10^{-3}) \\ t = 0.556 & t = 3.90^* & t = 0.90 \end{array}$$

$$R^2 = 0.26$$

*Significant at $\alpha = 0.05$; $\alpha = 0.01$

The regression coefficient of F is significant, however the R^2 value is low. Costs are continually decreasing with increases in case-flow.

Comparing the above three functions, there are minimal appreciable differences in the R^2 values, and consequently little basis upon which to determine the best fit. Costs decrease throughout the relevant range with increases in case-flow.

Overall Results

Table 13 compares the functions for all hospitals and case-mix groups in terms of explanatory power. There is little basis upon which to choose between the quadratic and inverse forms of the equations for all groups, with the exception of groups I, III and VI. For these three groups, the average cost curves are clearly U-shaped. Groups I and III depict that average costs increase, with increases in case-flow rates, as indicated by the positive regression coefficient on F and inverted U-shaped cost curves. The predictive power for all groups is relatively low.

Partial derivatives were calculated for nursing administration costs in order to determine optimal case-flow rates. An examination of these results will provide greater insight into the interpretation of the above results.

Part 2: Expected Optimal Case-Flow

Table 14 presents the expected optimal case-flow rates for average nursing administration cost functions.

TABLE 13

ESTIMATED RELATIONSHIPS BETWEEN AVERAGE NURSING ADMINISTRATION COSTS AND CASE-FLOW AND HOSPITAL SIZE

TOTAL SAMPLE AND CASE-MIX GROUPS, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Specification	$\hat{C} = \alpha_0 + \alpha_1 F + \alpha_2 B$	$\hat{C} = \alpha_0 + \alpha_1 F + \alpha_2 F^2 + \alpha_3 B + \alpha_4 B^2$	$\hat{C} = \alpha_0 + \alpha_1 F^{-1} + \alpha_2 B$
Total Sample	$\hat{C} = 17.9 - .272F + 7.3\times10^{-4}B$ (1.70) (4.69×10^{-2}) (2.46×10^{-3}) t=10.53 -5.80 -0.30 $R^2=0.23$	$\hat{C} = 29.5 - .978F + 1.0\times10^{-2}F^2 - 2.17\times10^{-3}B + 0.0B^2$ (3.60) (.206) (2.84×10^{-3}) (8.84×10^{-3}) (1.0×10^{-5}) t=8.18* -4.76* 3.52 -0.246 0.259 $R^2=0.31$	$\hat{C} = .385 + 251.2F^{-1} + 4.8\times10^{-4}B$ (1.07) (29.9) (2.18×10^{-3}) t=0.361 8.39* 0.222 $R^2=0.39$
Group I	$\hat{C} = 7.92 - .014F - 7.6\times10^{-3}B$ (2.76) (.069) (0.27) t=2.87* -0.21 -0.29 $R^2=0.004$	$\hat{C} = 5.44 + .417F - 5.61\times10^{-3}F^2 - .245B + 1.83\times10^{-3}B^2$ (5.88) (.277) (3.44×10^{-3}) (.063) (4.6×10^{-4}) t=0.93 1.51 -1.63 -3.88* 3.97* $R^2=0.44$	$\hat{C} = 8.84 - 49.2F^{-1} + 7.23\times10^{-3}B$ (2.58) (79.3) (2.64×10^{-2}) t=3.42* -0.620 -0.274 $R^2=0.02$
Group II	$\hat{C} = 14.0 - .192F + 1.3\times10^{-3}B$ (1.97) (5.36×10^{-2}) (1.82×10^{-3}) t=7.11* -3.58* 0.71 $R^2=0.23$	$\hat{C} = 19.0 - .475F + 3.99\times10^{-3}F^2 - 2.87\times10^{-3}B + 0.0B^2$ (6.86) (4.10) (5.81×10^{-3}) (7.53×10^{-3}) (1.0×10^{-5}) t=2.77* -1.16 0.687 -0.382 0.597 $R^2=0.25$	$\hat{C} = .931 + 209.3F^{-1} + 1.59\times10^{-3}B$ (1.66) (53.7) (1.77×10^{-3}) t=0.556 3.90* 0.900 $R^2=0.26$
Group III	$\hat{C} = 10.3 - 4.12\times10^{-2}F - 5.28\times10^{-2}B$ (4.08) (.130) (5.58×10^{-2}) t=2.52* -0.32 -0.945 $R^2=0.09$	$\hat{C} = 4.09 + .893F - 1.57\times10^{-2}F^2 + 1.57\times10^{-2}B - 7.6\times10^{-4}B^2$ (19.2) (1.23) (2.04×10^{-2}) (.288) (3.63×10^{-3}) t=-0.21 0.726 -0.768 0.054 -0.211 $R^2=0.13$	$\hat{C} = 8.62 + 14.4F^{-1} - 5.60\times10^{-2}B$ (4.40) (104.3) (5.52×10^{-2}) t=1.96 0.138 -1.01 $R^2=0.08$

*Significant at $\alpha = 0.05$

TABLE 13 (Continued)

Specification	$\hat{C} = \alpha_0 + \alpha_1 F + \alpha_2 B$	$\hat{C} = \alpha_0 + \alpha_1 F + \alpha_2 F^2 + \alpha_3 B + \alpha_4 B^2$	$\hat{C} = \alpha_0 + \alpha_1 F^{-1} + \alpha_2 B$
Group IV	$\hat{C} = 14.3 - .185F - 3.06\text{x}10^{-3}B$ $(3.18)\ (7.40\text{x}10^{-2})\ (5.55\text{x}10^{-3})$ $t=4.50^{*}\ \ -2.49^{*}\ \ -0.55$ $R^2=0.18$	$\hat{C} = 14.2 - .359F + 2.66\text{x}10^{-3}F + 4.62\text{x}10^{-2}B - 9.0\text{x}10^{-5}B^2$ $(8.67)\ (.423)\ (5.05\text{c}10^{-3})\ (1.98\text{x}10^{-2})\ (3.0\text{x}10^{-5})$ $t=1.63\ \ -0.85\ \ 0.527\ \ 2.34^{*}\ \ -2.58^{*}$ $R^2=0.35$	$\hat{C} = .215 + 248.6F^{-1} - 2.09\text{x}10^{-3}B$ $(2.81)\ (103.3)\ (5.48\text{x}10^{-3})$ $t=0.077\ \ 2.41^{*}\ \ -0.382$ $R^2=0.17$
Group V	$\hat{C} = 12.7 - .146F - 5.01\text{x}10^{-3}B$ $(2.35)\ (5.81\text{x}10^{-2})\ (6.92\text{x}10^{-3})$ $t=5.39^{*}\ \ -2.52^{*}\ \ -0.724$ $R^2=0.15$	$\hat{C} = 16.7 - .516F + 4.80\text{x}10^{-3}F^2 + 4.87\text{x}10^{-2}B - 9.0\text{x}10^{-5}B^2$ $(6.46)\ (.317)\ (3.79\text{x}10^{-3})\ (2.97\text{x}10^{-2})\ (5.0\text{x}10^{-5})$ $t=2.59^{*}\ \ -1.63\ \ 1.27\ \ 1.64\ \ -1.85$ $R^2=0.25$	$\hat{C} = 1.14 + 209.5F^{-1} - 4.35\text{x}10^{-3}B$ $(2.15)\ (72.0)\ (6.70\text{x}10^{-3})$ $t=0.533\ \ 2.91^{*}\ \ -0.649$ $R^2=0.19$
Group VI	$\hat{C} = 27.8 - .437F - 6.93\text{x}10^{-3}B$ $(4.92)\ (.156)\ (1.04\text{x}10^{-2})$ $t=5.66^{*}\ \ -2.79^{*}\ \ -0.67$ $R^2=0.36$	$\hat{C} = 41.7 - 1.70F + 2.18\text{x}10^{-2}F^2 + 3.93\text{x}10^{-2}B - 6.0\text{x}10^{-5}B^2$ $(9.42)\ (.723)\ (1.28\text{x}10^{-2})\ (5.42\text{x}10^{-2})\ (7.0\text{x}10^{-5})$ $t=4.42^{*}\ \ -2.36^{*}\ \ 1.71\ \ 0.72\ \ -0.80$ $R^2=0.51$	$\hat{C} = 154.9 + 293.8F^{-1} + .161B$ $(36.0)\ (618.2)\ (.109)$ $t=4.31^{*}\ \ 0.475\ \ 1.47$ $R^2=0.13$

*Significant at $\alpha = 0.05$.

TABLE 14[1]

EXPECTED OPTIMAL CASE-FLOW FOR NURSING ADMINISTRATION COST FUNCTIONS, TOTAL SAMPLE AND CASE-MIX GROUPS, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Hospital Groups	Total Sample	I	II	III	IV	V	VI
Expected Optimal Case-Flow	48.9	37.2*	59.5	28.4*	67.5	53.8	39.0

[1] Calculated from table 13.

In reference to the above table, the case-flow rates depicted with an asterisk indicate those rates which result in maximization of average costs.

All hospitals were estimated to be operating at 69.7 percent of the case-flow rate which would result in lowest costs per case; group II at 58.2 percent; group IV at 57.5 percent; group V at 68.6 percent and group VI at 74.1 percent. These findings suggest that perhaps there was an under-utilization of existing plant capacity and, therefore, higher unit costs. Groups I and III show optimal case-flow rates which maximize costs per case. The actual mean case-flow for group I is 36.1, and for group III is 31.3. The latter group has a case-flow rate which was greater than 28.4 cases per bed, which was estimated to produce maximum costs. All hospitals in group III have a rated bed capacity of less than 99 beds, the majority being within the 1-24 size class. It is possible that nursing administrative overhead is exceptionally high in these hospitals for the number of cases treated per bed year. These results are in direct contrast to the results obtained for group III in terms of general administration costs, where this group was shown to be operating at the highest degree of efficiency with respect to optimal case-flow.

Section III: The Analysis of Average Nursing Service Cost Relationships

Part 1: Average Nursing Service Costs and Case-Flow

In the short-run, total nursing service costs are hypothesized to be variable costs. Based on a given plant capacity, average cost curves were ascertained using linear, quadratic and inverse regression models for all hospitals and case-mix groups. The basic specifications set out in II-1 to II-3 are followed.

Regression Results

Three examples of estimated relationships according to the above specifications are detailed for group III hospitals.

Linear Form

$$\hat{C} = 288.1 - 2.89F + 1.46\times10^{-2}B \tag{II-10}$$

$$\begin{array}{ccc} (2.74) & (.875) & (.375) \\ t = 8.33^{*} & t = 3.30^{*} & t = 0.039 \\ & & R^2 = 0.47 \end{array}$$

*Significant at $\alpha = 0.05$; $\alpha = 0.01$

Statistical significance occurs for the intercept term and the regression coefficient of F. Costs per case decrease with increases in case-flow, however they increase with hospital size. The actual mean case-flow rate is 31.3, and the mean cost per case is \$138.00. It is observed from the equation that the predicted mean cost per case is \$140.89. The R^2 value is moderate.

U-Shaped Form

$$\text{(II-11)} \qquad \begin{array}{lllll} \hat{C} = 273.7 & - 3.51F & + 2.75\times10^{-2}F^2 & - 3.48B & + 4.5\times10^{-2}B^2 \\ \quad (110.7) & (7.08) & (.117) & (1.66) & (2.09\times10^{-2}) \\ t = 2.47^{*} & t = -0.50 & t = 0.234 & t = -2.10 & t = 2.165 \\ & & & & R^2 = 0.63 \end{array}$$

*Significant at $\alpha = 0.05$.

Although only the intercept term in this equation is statistically significant at the five percent level, the R^2 value connotes a good fit. Cost per case decreases, reaches a minimum of $F = 63.8$, and then beings to rise.

Inverse Form

$$\text{(II-12)} \qquad \begin{array}{lll} \hat{C} = 68.3 & + 2145.9F^{-1} & - 8.05\times10^{-2}B \\ \quad (31.1) & (737.3) & (.390) \\ t = 2.20^{*} & t = 2.91^{*} & t = -0.206 \\ & & R^2 = 0.41 \end{array}$$

*Significant at $\alpha = 0.05$

For the inverse function, the intercept term and the regression coefficient of F are statistically significant at the five percent level. Average nursing service costs are decreasing throughout the relevant range. Comparing the previous three equations, clearly, the U-shaped cost curve implies the best explanatory power.

Overall Results

Table 15 gives an overview of estimated relationships for all hospitals and case-mix groups. There is no evidence to suggest that the quadratic equations conclusively provide the best fits; however, in all instances they are as good as or better in terms of predictive power than the inverse or linear models. For group III, the quadratic equation undoubtedly has the best fit. All quadratic equations show that average nursing service costs decrease with increases in case-flow, and rise with increases in the number of hospital beds.

These findings do not support the basic premise that average nursing service cost curves would be U-shaped, indicating that the reciprocal total costs would be variable. This phenomenon suggests that hospitals sub-divided by case-mix classification are possibly under-utilized, as shown by the fact that hospitals have not reached their optimal level in terms of case-flow, which would minimize costs. The estimated optimal case-flow rates for each case-mix group substantiates this inference.

Part 2: Expected Optimal Case-Flow

Table 16 depicts the implied turning points in average nursing service cost functions.

All hospitals considered collectively are operating at 65.2 percent of optimal capacity utilization; group I at 40.0 percent; group II at 18.3 percent; group III at 49.1 percent; group IV at 63.9 percent; group V at 56.9 percent; and group VI at 78.8 percent.

TABLE 15

ESTIMATED RELATIONSHIPS BETWEEN AVERAGE NURSING SERVICE COSTS AND CASE-FLOW AND HOSPITAL SIZE TOTAL SAMPLE AND CASE-MIX GROUPS, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Specification	$\hat{C} = \alpha_0 + \alpha_1 F + \alpha_2 B$	$\hat{C} = \alpha_0 + \alpha_1 F + \alpha_2 F^2 + \alpha_3 B + \alpha_4 B^2$	$\hat{C} = \alpha_0 + \alpha_1 F^{-1} + \alpha_2 B$
Total Sample	$\hat{C} = 232.0 - 2.82F + .155B$ $(10.5)\ (.288)\ (1.51\text{x}10^{-2})$ $t=22.18\ -9.78\ 10.28$ $R^2=0.67$	$\hat{C} = 320.9 - 8.71F + 8.32\text{x}10^{-2}F^2 + .311B - 1.7\text{x}10^{-4}B^2$ $(20.6)\ (1.18)\ (1.63\text{x}10^{-2})\ (5.06\text{x}10^{-2})\ (5.0\text{x}10^{-5})$ $t=15.56^*\ -7.40^*\ 5.12^*\ 6.14^*\ -3.08$ $R^2=0.74$	$\hat{C} = 59.8 + 2307.1F^{-1} + .168B$ $(6.27)\ (176.1)\ (1.28\text{x}10^{-2})$ $t=9.53^*\ 13.10^*\ 13.12^*$ $R^2=0.76$
Group I	$\hat{C} = 167.9 - 1.46F + .246B$ $(15.4)\ (.386)\ (.149)$ $t=10.9^*\ -3.78^*\ 1.65$ $R^2= .37$	$\hat{C} = 214.0 - 2.69F + .015F^2 - .795B + 8.06\text{x}10^{-3}B^2$ $(39.2)\ (1.85)\ (.023)\ (.422)\ (3.08\text{x}10^{-3})$ $t=5.48^*\ -1.46\ 0.651\ -1.88\ 2.61^*$ $R^2=0.49$	$\hat{C} = 69.4 + 1556.4F^{-1} + .249B$ $(15.1)\ (463.4)\ (.154)$ $t=4.60^*\ 3.36^*\ 1.61$ $R^2=0.32$
Group II	$\hat{C} = 277.2 - 2.61F + .151B$ $(13.9)\ (.377)\ (.013)$ $t=16.4^*\ -6.93^*\ 11.8^*$ $R^2=0.82$	$\hat{C} = 226.6 - 3.10F + 8.19\text{x}10^{-3}F^2 + .281B - 1.4\text{x}10^{-4}B^2$ $(45.4)\ (2.71)\ (3.85\text{x}10^{-2})\ (4.98\text{x}10^{-2})\ (5.0\text{x}10^{-5})$ $t=4.97^*\ -1.14\ 0.213\ 5.63^*\ -2.69^*$ $R^2=0.85$	$\hat{C} = 60.6 + 2462.2F^{-1} + .157B$ $(12.8)\ (410.0)\ (1.35\text{x}10^{-2})$ $t=4.73^*\ 6.00^*\ 11.66^*$ $R^2=0.80$
Group III	$\hat{C} = 288.1 - 2.89F + 1.46\text{x}10^{-2}B$ $(27.4)\ (.875)\ (.375)$ $t=8.33^*\ -3.30^*\ 0.039$ $R^2=0.47$	$\hat{C} = 273.7 - 3.51F + 2.75\text{x}10^{-2}F^2 - 3.48B + 4.52\text{x}10^{-2}B^2$ $(110.7)\ (7.08)\ (.117)\ (1.66)\ (2.09\text{x}10^{-2})$ $t=2.47^*\ -0.50\ -0.234\ -2.096\ 2.165$ $R^2=0.63$	$\hat{C} = 68.3 + 2145.9F^{-1} - 8.05\text{x}10^{-2}B$ $(31.1)\ (737.3)\ (.390)$ $t=2.20^*\ 2.91^*\ -0.206$ $R^2=0.41$

*Significant at $\alpha = 0.05$

TABLE 15 (Continued)

Specification	$\hat{C}= \alpha_0 + \alpha_1F + \alpha_2B$	$\hat{C}= \alpha_0 + \alpha_1F + \alpha_2F^2 + \alpha_3B + \alpha_4B^2$	$\hat{C}= \alpha_0 + \alpha_1F^{-1} + \alpha_2B$
Group IV	$\hat{C} = 214.9 - 2.38F + .197B$ $(15.6)\quad(.363)\quad(2.72\text{x}10^{-2})$ $t=13.8^*\quad -6.57^*\quad 7.23^*$ $R^2=0.84$	$\hat{C} = 277.4 - 6.68F + 5.50\text{x}10^{-2}F^2 + .496B - 5.4\text{x}10^{-4}B^2$ $(36.5)\quad(1.78)\quad(.021)\quad(.083)\quad(1.5\text{x}10^{-4})$ $t=7.60^*\quad -3.75^*\quad 2.59^*\quad 5.96^*\quad -3.70^*$ $R^2=0.90$	$\hat{C} = 28.6 + 3388.8F^{-1} + .206B$ $(13.1)\quad(483.0)\quad(2.56\text{x}10^{-2})$ $t=2.18^*\quad 7.02^*\quad 8.06^*$ $R^2=0.85$
Group V	$\hat{C} = 202.0 - 217\text{x}10^{-3}F + .215B$ $(11.8)\quad(.291)\quad(3.47\text{x}10^{-2})$ $t=17.2^*\quad -7.44^*\quad 6.21^*$ $R^2=0.76$	$\hat{C} = 243.2 - 5.43F + 4.19\text{x}10^{-2}F^2 + .599B - 6.7\text{x}10^{-4}B^2$ $(29.4)\quad(1.44)\quad(1.72\text{x}10^{-2})\quad(.135)\quad(2.3\text{x}10^{-4})$ $t=8.27^*\quad -3.77^*\quad 2.43^*\quad 4.43^*\quad -2.90^*$ $R^2=0.83$	$\hat{C} = 41.7 + 2737.2F^{-1} + .230B$ $(11.1)\quad(372.5)\quad(3.46\text{x}10^{-2})$ $t=3.75^*\quad 7.35^*\quad 6.63^*$ $R^2=0.76$
Group VI	$\hat{C} = 284.9 - 4.0F + .140B$ $(32.5)\quad(1.03)\quad(6.86\text{x}10^{-2})$ $t=8.77^*\quad -3.87^*\quad 2.04$ $R^2=0.56$	$\hat{C} = 437.9 - 17.6F + .240F^2 + .310B - 1.8\text{x}10^{-4}B^2$ $(49.7)\quad(3.81)\quad(6.75\text{x}10^{-2})\quad(.286)\quad(3.7\text{x}10^{-4})$ $t=8.80^*\quad -4.60^*\quad 3.55^*\quad 1.08\quad -0.47$ $R^2=0.79$	$\hat{C} = 72.8 + 2153.6F^{-1} + .169B$ $(18.0)\quad(339.4)\quad(5.08\text{x}10^{-2})$ $t=4.04^*\quad 6.35^*\quad 3.34^*$ $R^2=0.76$

*Significant at $\alpha = 0.05$

TABLE 16[1]

EXPECTED OPTIMAL CASE-FLOW FOR NURSING SERVICE COST FUNCTIONS, TOTAL SAMPLE AND CASE-MIX GROUPS, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Hospital Groups	Total Sample	I	II	III	IV	V	VI
Expected Optimal Case-Flow	52.3	90.3	189.3	63.8	60.7	64.8	36.7

[1] Calculated from table 15.

Group II hospitals, with an average case-flow rate of 34.6 are operating well below the optimal case-flow rate (189.3), which would minimize nursing service costs. This group of hospitals contains six of the seven hospitals with a rated bed capacity of 300 beds and over. From a practical stance, it is possible that patients in this group of hospitals experience longer average lengths of hospitalization than patients in the remaining groups. This situation would, therefore, result in fewer patients being treated over a period of time. Therefore, the average cost per case for group II hospitals would be high. In order to more fully understand the significance of the interpretation, it would be necessary to examine actual average lengths of stay rates and percentage occupancy, as well as the factors of production for nursing services, for example, labour inputs.

For all case-mix groups, it would appear that if case-flow rates were increased, average nursing service costs would be substantially reduced.

Economic Observations: A Summary Overview

In order to estimate the effect of variations in case-flow upon average general administration costs, average nursing administration costs, and average nursing service costs in the short-run on hospitals classified according to case-mix, ordinary least squares regression estimates using linear, quadratic and inverse models were determined. A measure of hospital size was included in each equation to hold plant capacity constant.

Empirical results showed that estimations of average general administration costs deviated little from theoretical expectations, that is, cost curves were found to be the shape of rectangular hyperbolas, although the findings were inconclusive as the quadratic equations generally provided fits as good as the inverse form of the equations.

With the exception of groups I and III, which clearly depicted U-shaped cost curves with average costs rising with increases in output, there was little basis for choosing between the quadratic equations and inverse form of the equations for average nursing administration costs.

For average nursing service costs there is no evidence to suggest that the quadratic equations conclusively provide the best fits, although for all groups the quadratic equations depicting U-shaped cost curves provide fits as good or better than either the linear model or the inverse form.

Expected optimal case-flow rates were determined for each cost. The results indicated that most case-mix groups have actual mean case-flow rates considerably below those estimated rates which would minimize costs. For average general administration costs, group III was found to be operating more closely to its optimal capacity utilization than any other group. For nursing administration costs, the reverse was found. Group III hospitals have an actual mean case-flow rate exceeding that rate which would result in maximum costs, and group I hospitals have an estimated case-flow rate which maximizes average nursing administration costs. Expected optimal case-flow rates for case-mix groups considering average nursing costs showed that all groups were operating well below their optimal level of activity, particularly group II hospitals.

In conclusion, accounting for case-mix specification in estimating cost-output relationships provides a useful basis upon which to analyze hospital costs and efficiency, a basis which has been ignored by researchers in the hospital sector until very recently.

CHAPTER V

SUMMARY OF MAJOR FINDINGS, OBSERVATIONS AND SUGGESTIONS

Summary

This chapter presents a summary of the major findings of this study, and related observations and suggestions. Chapter III dealt with short-run econometric relationships between three average hospital costs (general administration, nursing administration, and nursing service), and case-flow rates on a sample of 108 General Public Hospitals in Alberta for 1971 sub-divided into size classes according to rated bed capacity. The size classes were as follows: 1-24 beds; 25-49 beds; 50-99 beds; 100-299 beds; and 300 beds and over. No analyses were carried out on the latter group as there were too few hospitals for meaningful statistical interpretation. For purposes of this study, it was assumed that the case-mix within each size class was similar. Empirical results were obtained by applying ordinary least squares regression analyses, using three specifications: linear; quadratic; and the inverse form of the equation.

The results indicate that average general administration and average nursing administration costs comply with theoretical expectations; that is, the inverse form of the equation provides as good a fit or better than either the linear or quadratic equations for all size classes. Contrary to theoretical expectations, average cost curves for nursing service were found to be L-shaped, with the exception of the group of hospitals ranging in size from 100 to 299 beds, in which case the cost curve was depicted as being U-shaped.

Further analyses were carried out to account for the variation in hospital size within the size classes, by including a measure of plant capacity in each equation. The findings demonstrated that inter-class variation had little effect upon the estimated relationships for all three average costs in all size classes, with two exceptions. Firstly, the R^2 value for the estimated relationship between average nursing administration costs and case-flow in the quadratic equation improved substantially with the addition of the scale factor for the 100-299 size class. This change indicates that the average nursing administration cost curve is U-shaped for this group. The remaining groups continued to depict L-shaped cost curves. Secondly, the R^2 values for nursing service costs for all three specifications improved markedly in the 100-299 size class, which suggests that it is necessary to include a measure of plant capacity when estimating short-run relationships between costs and output for hospital size classes with a wide range of capacity.

An analysis of covariance using a linear model was done to determine whether differences exist in estimated relationships between size classes. The 25-49 size class was the base group. Significant differences were found between the 50-99 size class and the base group for each of the three average costs.

In chapter IV the relationships between the aforementioned average costs and case-flow were investigated accounting for case-mix variation. Six case-mix groups from the total sample of 115 General Public Hospitals for the year 1971 were previously identified. Groups I to V inclusive correlated at 0.8 or greater in case-mix composition, whereas group VI hospitals did not have high enough correlations to be representative of a particular case-mix. These groups were not mutually exclusive.

Least squares estimates were obtained by including a measure of hospital size in each regression equation. Linear, quadratic, and the inverse form of the equation were the models used for estimations. Considering average general administration costs, all groups with the exception of group III hospitals depicted the inverse form of the equation as having as good a fit as the quadratic equations. The average cost curve for group III hospitals is more clearly U-shaped. Considering average nursing administration costs, the quadratic equation seemingly provided the best fit, with the exception of group II hospitals where there was no improvement over the inverse form of the equation. These findings imply that there is no conclusive evidence that average nursing administration costs are L-shaped. Nursing administration costs which were anticipated to depict L-shaped curves on a priori grounds, were generally found to be U-shaped. Groups I and III depicted that average costs increase with increases in case-flow. With the exception of group III hospitals, which depicted a U-shaped cost curve, there was little basis upon which to choose between the inverse form of the equation and the quadratic equation for nursing service costs.

Expected optimal case-flow rates for the case-mix groups were determined for each of the three types of average cost. For general administration costs, all groups were noted to be operating below the optimal output level which would minimize costs; however group III hospitals more closely approximated the optimal output level. In the case of nursing administration costs, all groups, with the exception of groups I and III, showed a substantial under-utilization of plant capacity. Groups I and III on the other hand, were found to have actual mean case-flow rates which result in the maximization of average costs, suggesting a high nursing administrative overhead for these hospitals. Estimated optimal case-flow rates for nursing service costs were computed to be higher than the actual mean case-flow rates for all groups. The most notable observation is for group II hospitals, which are actually operating well below their optimal output rates. As this group consists of most of the largest hospitals (six of the total number range in capacity from 555 to 1068 beds), it may be concluded that larger hospitals tend to use capacity less intensively.

The principle finding, therefore, is a confirmation that more intensive hospital utilization (i.e., higher case-flow rates) results in a decrease of costs per case for average general administration costs; average nursing administration costs; and average nursing service costs, with the exception of average nursing administration costs for groups I and III, which were found to increase.

Observations and Suggestions

By increasing the number of admissions per bed per year, and decreasing the average length of hospital stay, it is observed that, on the whole, the three selected average costs per case would decrease. Longer hospital stays may reflect a higher quality of care or, conversely, an inefficient use of resources. From the policy standpoint on the basis of this study, it is not known what the effect of increasing the number of admissions and reducing average length of stay would have on the quality of care. For major policy purposes, it would be necessary to examine total average cost relationships as well as total benefits received as case-flow increases.

It is suggested that health services personnel, especially medical practitioners and hospital administrators, be made aware that by increasing the number of patients treated in hospital per year and by decreasing the length of hospital stay, average general administration costs, average nursing administration costs and average nursing service costs and, therefore, total costs per case could be reduced.

In the course of the literature review for this study, it became apparent that there are serious limitations in the adequacy and validity of output measures. There is scant empirical evidence as to how hospital costs really behave. In order to obtain more reliable and replicable studies of hospital costs, standard specifications are needed. The categorization of hospitals on the basis of case-mix composition does provide a useful method of examining hospital output.

Expenditures on health care, and in particular costs in the hospital sub-sector have been escalating rapidly causing intense concern to Canadian governments, particularly at the provincial level. It is suggested that further research should be undertaken on both hospital production and cost functions, aimed at providing improved bases for policy decision-makers to improve the efficiency of hospital services.

Although this study was restricted to the narrow cost side of econometric relationships in the short-run, the empirical estimates are useful indicators of the behaviour of administrative and nursing service cost behaviour in general hospitals. It is desirable that any additional research also include estimates of long-run cost functions to examine the fundamental question of the extent to which economies or diseconomies of scale exist in hospitals.

From an administrative point of view, the results of this study deviated little from theoretical expectations.

SELECTED REFERENCES

Books

Berki, Sylvester E. Hospital Economics. Lexington, Massachusetts: D.C. Heath and Company, 1972.

Dean, Joel. "Statistical Cost Functions of a Hosiery Mill." In Statistical Cost Analysis. Edited by J. Johnston. New York: McGraw-Hill Book Company, Inc., 1960.

Feldstein, Martin S. Economic Analysis for Health Service Efficiency. Chicago: Markham Publishing Company, 1968.

________. The Rising Cost of Hospital Care. Washington: Information Resources Press, 1971.

Feldstein, Paul J. An Empirical Investigation of the Marginal Cost of Hospital Services. Chicago: University of Chicago, 1961.

Francisco, Edgar W. "Analysis of Cost Variations Among Short-Term General Hospitals." In Empirical Studies in Health Economics. Edited by A.E. Klarman. Baltimore: Johns Hopkins Press, 1970.

Fraser, R.D. Canadian Hospital Costs and Efficiency. Prepared for the Economic Council of Canada. Ottawa: Information Canada, 1971.

Friedman, Milton. Price Theory. Chicago: Aldine Publishing Company, 1967.

Greenfield, Harry I. Hospital Efficiency and Public Policy. New York: Praeger Publishers, 1973.

Johnston, J. Statistical Cost Analysis. New York: McGraw-Hill Book Company, Inc., 1960.

________. Econometric Methods. 2nd ed. New York: McGraw-Hill Book Company, Inc., 1972.

Kaitz, Edward M. Pricing Policy and Cost Behaviour in the Hospital Industry. New York: Praeger Publishers, 1968.

Klarman, Herbert E. The Economics of Health. New York: Columbia University Press, 1965.

Lancaster, K. Introduction to Modern Microeconomics. Chicago: Rand, McNally and Company, 1969.

Leftwich, Richard H. The Price System and Resource Allocation. Illinois: The Dryden Press Inc., 1970.

Mansfield, Edwin. Microeconomics: Theory and Applications. New York: W.W. Norton and Company, Inc., 1970.

Markham, Jesse W. "Competition in the Rayon Industry." In Statistical Cost Analysis. Edited by J. Johnston. New York: McGraw-Hill Book Company, Inc., 1960.

Migué, Jean Luc, and Bélanger, Gérard. The Price of Health. Toronto: The Macmillan Company of Canada Limited, 1974.

Montachute, Charles. Costing and Efficiency in Hospitals. London: Oxford University Press, 1962.

Ruchlin, Hirsch S., and Rogers, Daniel C. Economics and Health Care. Springfield, Illinois: Charles C. Thomas, Publisher, 1973.

Samuelson, Paul A., and Scott, Anthony. Economics. Toronto: McGraw-Hill Company of Canada Limited, 1971.

Wonnacott, Ronald J., and Wonnacott, Thomas H. Econometrics. New York: John Wiley and Sons, Inc., 1970.

Articles

Berry, Ralph E. "Returns to Scale in the Production of Hospital Services." Health Services Research 2 (Summer 1967): 123-139.

Brown, Max. "An Economic Analysis of Hospital Operations." Hospital Administration 15 (Spring 1970): 60-74.

Cohen, H.A. "Variations in Costs Among Hospitals of Different Sizes." Southern Economic Journal 33 (January 1967): 355-366.

Eiteman, Wilfred J., and Guthrie, Glenn E. "The Shape of An Average Cost Curve." American Economic Review 42 (December 1952): 832-838.

Elnicki, Richard A. "Hospital Productivity, Service Intensity, and Costs. Health Services Research 9 (Winter 1974): 270-292.

Evans, R.G. "Behavioural Cost Functions For Hospitals." Canadian Journal of Economics 4 (May 1971): 198-213.

________., and Walker, Hugh D. "Information Theory and the Analysis of Hospital Cost Structure." The Canadian Journal of Economics 5 (August 1972): 398-418.

Fair, J.S. "A Concrete Approach to More Effective Bed Utilization." *Hospital Administration in Canada* 12 (July 1970): 41-45.

Feldstein, Paul J. "Applying Economic Concepts to Hospital Care." *Hospital Administration* 13 (Winter 1968): 68-69.

Financial Post, 16 December 1972

Financial Times of Canada, 8 January 1973.

Hefty, T.R. "Returns to Scale in Hospitals: A Critical Review of Recent Research." *Health Services Research* 4 (Winter 1969): 267-280.

Jeffers, James R., and Siebert, Calvin D. "Measurement of Hospital Cost Variation: Case-Mix, Service Intensity, and Input Productivity Factors." *Health Services Research* 9 (Winter 1974): 293-307.

Lave, Judith R., and Lave, Lester B. "Hospital Cost Functions." *American Economic Review* 60 (June 1970): 379-395.

________. "The Extent of Role Differentiation Among Hospitals." *Health Services Research* 6 (Spring 1971): 15-38.

Newhouse, Joseph P. "Toward a Theory of Non-Profit Institutions: An Economic Model of a Hospital." *American Economic Review* 60 (March 1970): 64-74.

Saathoff, Donald E., and Kurtz, Richard A. "Cost Per Day Comparisons Don't Do The Job." *The Modern Hospital* 99 (October 1962): 14-16.

Simms, Graham. "A Critical Review of Fiscal and Administrative Controls on Costs and Use in Canada." *Medical Care* 7 (November-December 1969): 63-74.

Thompson, John D. "On Reasonable Costs of Hospital Services." *Millbank Memorial Fund Quarterly* 46 (January 1968): 33-51.

Walters, A.A. "Production and Cost Functions: An Economic Survey." *Econometrica* 31 (January 1963): 1-52.

Other Sources

Bay, K.; Flathman, D.; and Plain R. "An Application of Q-Type Factor Analysis for Grouping Hospitals Based on Case-Mix Profiles." Division of Health Services Administration, The University of Alberta, Edmonton, 1971 (Mimeographed).

Harrison, Fernande. Health Services Administrator, Alberta Hospital Services Commission, Edmonton, Alberta. Interview, 15 October 1974.

Riley, Charles Frederick. "An Examination of the Economic Literature Pertaining to the Behaviour of Costs in General Acute Hospitals." M.H.S.A. thesis, University of Alberta, 1974.

1972 Instructions and Definitions for the Annual Return of Hospitals. Form HS-2 Financial. Ottawa: Statistics Canada, 1972.

1972 Instructions and Definitions for the Annual Return of Hospitals. Form HS-1 Facilities and Services. Ottawa: Statistics Canada, 1972.

1971 Financial and Statistical Tables For Alberta Hospitals. Alberta Hospital Services Commission, 1971 (Mimeographed).

APPENDIX A

RATED BED CAPACITY OF HOSPITALS IN SIZE CLASSES, ALBERTA GENERAL PUBLIC HOSPITALS, 1971

RATED BED CAPACITY OF HOSPITALS IN SIZE CLASSES

ALBERTA GENERAL PUBLIC HOSPITALS, 1971

Size Class	Hospital	Rated Bed Capacity	Hospital	Rated Bed Capacity
	Bentley Municipal	16	Hardisty St. Anne's	20
	Berwyn Municipal	21	Hythe Municipal	10
	Bow Island General	20	Islay Municipal	12
	Canmore Municipal	22	Mannville Municipal	15
1 - 24	Carman Gay Little Bow Municipal	16	Mayerthorpe General	22
Beds	Cereal Municipal	9	Mundare Mary Immaculate	18
	Consort Municipal	22	Myrnam Municipal	20
	Devon Civic	7	Radway St. Joseph's	14
N = 22	Elnora General	16	Three Hills Municipal	22
	Empress Municipal	17	Turner Valley Municipal	24
	Glendon Municipal	8	Vilna Our Lady's	14
	Athabasca Municipal	45	Jasper Seton General	26
	Banff Mineral Springs	47	Killam General	30
	Bashaw General	30	Leduc Municipal	35
	Bassano General	30	Magrath Municipal	26
	Beaverlodge Municipal	30	Manning Municipal	34
25 - 49	Boyle General	30	Milk River Borden Co. General	30
Beds	Breton General	30	Olds Municipal	43
	Castor Our Lady of the Rosary	30	Oyen Big Country	34
	Claresholm General	39	Picture Butte Municipal	25
	Coaldale Community	25	Provost Municipal	34
N = 47	Cold Lake John Neil	27	Raymond Municipal	25
	Coronation Municipal	25	Rimbey General	31
	Daysland Providence General	30	Rocky Mtn. House Municipal	34
	Didsbury Municipal	32	Slave Lake General	34
	Drayton Valley Municipal	47	Smoky Lake George McDougall Mem.	25
	Eckville Municipal	26	Spirit River - Holy Cross	44

Size Class	Hospital	Rated Bed Capacity	Hospital	Rated Bed Capacity
	Fort MacLeod Municipal	32	Stony Plain Municipal	30
	Fort Vermilion St. Theresa Gen.	36	Sundre General	34
	Galahad St. Joseph's	40	Tofield Municipal	31
25 - 49	Grande Cache General	34	Trochu St. Mary's	31
Beds	Hinton Municipal	27	Two Hills Municipal	37
			Valleyview General	30
			Viking Municipal	35
			Vulcan Municipal	37
			Whitecourt General	34
			Willingdon Mary Immaculate	25
	Barrhead St. Joseph's	80	Innisfail General	55
	Blairmore Crows Nest Pass Munic.	60	Lac La Biche St. Catherine's	68
	Bonnyville St. Louis	52	Lacombe General	50
50 - 99	Brooks General	65	Lamont Archer Memorial	73
Beds	Cardston Municipal	61	McLennan Sacred Heart	59
	Drumheller General	70	Peace River Municipal	71
	Edson St. John's	50	Pincher Creek St. Vincent's	56
	Elk Point Municipal	51	Ponoka General	50
N = 29	Fairview Municipal	50	St. Paul St. Theresa General	75
	Fort McMurray General	54	Stettler General	50
	Fort Saskatchewan General	50	Taber General	71
	Hanna General	50	Vegreville St. Joseph General	70
	High Prairie Providence	72	Vermilion Municipal	52
	High River General	64	Wainwright General	54
	Calgary Salvation Army Grace	100	Lethbridge St. Michael's Gen.	207
	Calgary Rocky View General	194	Medicine Hat General	230
100-299	Camrose St. Mary's	117	Red Deer General	229
Beds	Grande Prairie Municipal	130	St. Albert Sturgeon General	100
N = 10	Lethbridge Municipal	207	Wetaskiwin Municipal	135

Size Class	Hospital	Rated Bed Capacity	Hospital	Rated Bed Capacity
300 + Beds N = 7	Calgary Foothills	766	Edmonton Misericordia	555
	Calgary General	952	Edmonton Royal Alexandra	976
	Calgary Holy Cross	513	Edmonton University of Alberta	1068
	Edmonton General	519		

Total N = 115

Total Rated Bed Capacity = 10413

APPENDIX B

CLASSIFICATION OF 115 GENERAL PUBLIC HOSPITALS IN ALBERTA, 1971 ACCORDING TO CASE-MIX COMPOSITION

CLASSIFICATION OF 115 GENERAL PUBLIC HOSPITALS IN ALBERTA, 1971
ACCORDING TO CASE-MIX COMPOSITION

Group I N = 33

Bashaw General
Bassano General
Bentley Municipal
Bonnyville St. Louis
Boyle General
Canmore Municipal
Claresholm General
Daysland Providence General
Devon Civic
Didsbury Municipal
Elk Point Municipal
Fort Vermilion St. Theresa General
Galahad St. Joseph's
Killam General
Lac La Biche St. Catherine's
McLennan Sacred Heart
Mannville Municipal
Mayerthorpe Municipal
Oyen Big Country
Pincher Creek St. Vincent's
Radway St. Joseph's
Raymond Municipal
Rimbey General
Rocky Mountain House General
Spirit River Central Peace General
Turner Valley Municipal
Vegreville St. Joseph's General
Viking Municipal
Vilna Our Lady's
Wetaskiwin Municipal
Willington May Immaculate
Whitecourt General
Sundre General

Group II N = 54

Banff Mineral Springs
Barrhead St. Joseph's
Bassano General
Blairmore Crows Nest Municipal
Brooks General
Calgary General
Calgary Holy Cross
Camrose St. Mary's
Cardston Municipal
Didsbury Municipal
Drayton Valley Municipal
Drumheller General
Eckville Municipal
Edmonton General
Edmonton Misericordia
Edmonton Royal Alexandra
Edmonton University of Alberta
Edson St. John's
Fairview Municipal
Fort McLeod Municipal
Fort Saskatchewan General
Grande Prairie Municipal
Hanna General
High River General
Hinton Municipal
Innisfail General
Lacombe General
Leduc Municipal
Lethbridge Municipal
Lethbridge St. Michael's General
Manning Municipal
Mannville Municipal
Medicine Hat General
Milk River Border Counties General
Olds Municipal
Peace River Municipal
Pincher Creek St. Vincent's
Ponoka General
Provost Municipal
Red Deer General
Rimbey General
Rocky Mountain House General
Stettler Municipal
St. Paul St. Theresa General

Taber General
Three Hills Municipal
Vegreville St. Joseph's General
Vermilion Municipal
Wainwright General
Westlock Immaculata
Wetaskiwin Municipal
Fort McMurray General
Slave Lake General
Grande Cache General

Group III N = 16

Breton General
Carmangay Little Bow Municipal
Cereal Municipal
Cold Lake John Neil
Coronation Municipal
Elk Point Municipal
Hardisty St. Anne's
Islay Municipal
Lacombe General
Myrnam Municipal
Oyen Big Country
Spirit River Holy Cross
Stettler Municipal
Vegreville St. Joseph's General
Viking Municipal
Vulcan Municipal

Group IV N = 31

Barrhead St. Joseph's
Beaverlodge Municipal
Cardston Municipal
Castor Our Lady
Didsbury Municipal
Drayton Valley Municipal
Edmonton General
Edmonton Misericordia
Fairview Municipal
Hanna General
Innisfail General
Lacombe General
Leduc Municipal
Lethbridge St. Michael's
Magrath Municipal
Medicine Hat General
Olds Municipal
Peace River Municipal
Pincher Creek St. Vincent's
Red Deer General
Rimbey General
Rocky Mountain House General
Smoky Lake George McDougall
Spirit River Holy Cross
Stony Plain Municipal
Taber General
Westlock Immaculata
Wetaskiwin Municipal
Whitecourt General
St. Albert Sturgeon General

Group V N = 39

Barrhead St. Joseph's
Bassano General
Bonnyville St. Louis
Brooks General
Cardston Municipal
Castor Our Lady
Claresholm Municipal
Cold Lake John Neil
Didsbury Municipal
Drayton Valley Municipal
Edmonton Misericordia
Elk Point Municipal
Fort McLeod Municipal
Fort McMurray General
Fort Saskatchewan General
Grande Prairie Municipal

HighPrairie Providence
High River General
Lacombe General
Leduc Municipal
McLennan Sacred Heart
Milk River Border Counties
Olds Municipal
Peace River Municipal Pi
Pincher Creek St. Vincent's
Rimbey General
Rocky Mountain House General
Slave Lake General
St. Albert Sturgeon General
St. Paul St. Theresa
Taber General
Three Hills Municipal
Two Hills Municipal
Valleyview General
Vegreville St. Joseph's General
Vermilion Municipal
Westlock Immaculata
Wetaskiwin Municipal
Whitecourt General

Group VI   N = 18

Athabaskca Municipal
Berwyn Municipal
Bow Island General
Calgary Foothills Provincial
Calgary Salvation Army Grace
Calgary Rockyview General
Coaldale Community
Consort Municipal
Elnora General
Empress Municipal
Glendon Municipal
Hythe Municipal
Jasper Seton General
Lamont Memorial
Mundare Mary Immaculate
Picture Butte Municipal
Tofield Municipal
Trocher St. Mary's